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DEPARTMENT BULLETIN No. 1386

Washington, D. C. ▼ July, 1926

SOME PANICLE CHARACTERS OF SORGO

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By

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Bureau of Plant Industry

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By HORACE B. COWGILL,[1] *Assistant Agronomist, Office of Sugar Plants, Bureau of Plant Industry*

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INTRODUCTION

A more complete knowledge than has hitherto been published of varietal differences in sorgo, the group of sorghums known as the saccharine group, is needed for the following purposes: (1) For distinguishing between sorts recognized by growers and between taxonomic forms and for classifying and making a key to them; (2) for determining the purity of sorts, since frequently, as cultivated, they are intermixtures of a number of more or less diverse races, and as such intermixtures often become intercrossed heterozygous forms also are frequently included; and (3) for use in the study of inheritance in breeding.

The need of making careful distinctions between types is doubtless greater where the crop is utilized for making sirup than where used as forage for livestock. In the former case the relative value of varieties is dependent upon definite requirements in the composition of the stalk, to a degree equal to or greater than that of tonnage yield of stalks obtainable per acre or than that of agronomic suitability. Although composition may have some significance also when

[1] Acknowledgment is due to James F. Brewer for much assistance in the photographic work.

the sorgos are used for forage, the requirements are evidently not so exacting, more latitude being permissible in the proportions of the various constituents contributing to the feeding value. Sugar is not produced commercially from this plant at the present time, but the sugars—sucrose, dextrose, and levulose—are the essential components of sirup made from its juice, and certain other components also contribute to flavor. In the United States at various times varieties have been examined from a chemical standpoint, and a number have also been tested experimentally and by growers regarding the actual yield and quality of sirup that may be obtained from them by the usual process of concentrating the juice, so that it is well known that there are marked differences in respect to sirup-making properties between some of them. A number of examples of varieties between which differences in sugar content are considerable, though visual differences are small or at least frequently not recognized by growers, might be cited. The following example is pertinent, as it shows that extensively cultivated kinds which differ widely as to saccharine properties are sometimes similar. Two awnless varieties, both of which have semicompact panicles and black or nearly black glumes, have shown in recent tests an average difference of 3 per cent in the amount of soluble solids and something over 3 per cent in the quantity of sugars in their juices. This is equal to an increase of more than one-sixth in solids and over one-fourth in sugars. There are many others, differing in visual characters that are not usually recognized by growers and seedsmen, which are so diverse in sugar content and other economic characters that it would be much more profitable to cultivate only certain ones and to discard all the others.

New sorts which differ more or less in appearance are continually being encountered. Some of them are grown only in particular localities; others are more widely cultivated and may be often found in communities in various States. Practically all seedsmen handle the seed of one or more varieties, and they become disseminated in this way. Some of them present the appearance of much homogeneity, but in some cases these are in reality mixtures of a number of somewhat similar forms. Others are very evidently impure. It is usually possible by continuous roguing to eliminate the more conspicuously diverse types from these commercial varieties. About 20 of the varieties upon which the present study is based were inbred for a series of years, and it was thus possible largely to eliminate forms which did not conform to the prevailing type. Although such a practice might not always be feasible commercially, as growers would doubtless find it somewhat difficult to make fine distinctions and might find it especially difficult to maintain pure races once they were obtained, the writer knows of one commercial firm which practices breeding based on tests of the sucrose content of individual stalks, the heads from the best-testing stalks being saved and the seed planted for increase. It would thus seem that with some knowledge of varietal characters it would be practicable to isolate and cultivate comparatively pure races which show superiority in sugar content or other economic characteristics. As varietal characters become better known, it should become increasingly feasible for both growers and seedsmen to distinguish the varieties grown and for the growers to make finer distinctions be-

tween minor forms. It will probably be found practicable for the growers to separate from the varieties now being grown a number of minor forms and to cultivate only those which, after being isolated, are found to be most desirable from the standpoints of yield, chemical composition, and the quality of the sirup produced.

Varieties of sorghum, some of which belong to the sorgo group, have been described more or less completely by European and American writers from pre-Linnean times until the present, the descriptions usually being more in detail where the number considered was large. Many of the characters which are presented here were employed by some of these earlier writers. Possibly some of our varieties bear closer resemblance than these earlier kinds. However this may be, these earlier descriptions are not generally complete enough to serve as models for distinguishing ours, nor is it possible from the descriptions to identify with certainty many of these earlier kinds. However, some of them were evidently similar to present-day varieties and, presumably, were the same, although known by different names. Some of the more recent descriptions of cultivated sorghums treating of both the sorgo and the grain-sorghum groups were given in greater detail than those published earlier, and some of the characters presented are useful in distinguishing varieties of the present time and in classifying them.

It is the purpose to present in this bulletin the results of an investigation of varietal characters in 30 or 40 kinds of sorgo grown by the Office of Sugar Plants of the Bureau of Plant Industry during the years 1918 to 1924, as well as to show points of similarity in groups of varieties. Only characters of the mature panicle are considered here. Although there are differences in regard to features of the stalks, branches, and leaves which it is hoped to present at another time, the greater number and somewhat more evident differences pertaining to form and structure of the mature panicle itself and to the form, structure, color, and pubescence of its axis, its branches, and the spikelets make the panicle of greater value for purposes of classification and identification than the vegetative parts. The panicle also is the part most easily preserved. Although the direction of branches is likely to be somewhat changed when specimens are dried and some changes also take place with the advance in maturity of the growing plant, there are many characters which are approximately assumed some time before the seeds are mature, which change very little after maturity even in specimens dried for the herbarium. No attempt is made to present a key to varieties at this time, as it has not been possible to make a study of all of them, and no study has been made of the nonsaccharine group. For the purposes of this bulletin, the latter are distinguished from the sorgos by lack of juiciness and sweetness in the pith, this being in accordance with the general classification by Ball and Rothgeb (*4*, p. 17).[2]

REVIEW OF THE LITERATURE

Types of both the saccharine and the grain sorghums, most of which it is to be presumed were taxonomic forms, have been de-

[2] The serial numbers (*italic*) in parentheses refer to "Literature cited," at the end of this bulletin.

scribed by early European and American botanical writers as well as by contemporaneous writers. A bibliography of sorghum, including works on classification, is given by Ball (*2*). Linné (*10*, p. 1047) listed three types as species in his "Species Plantarum," differentiating them as follows: (1) "Glumis villosis, feminibus aristatis, *Holcus sorghum*"; (2) "Glumis glabris, feminibus muticis, *Holcus saccharatus*"; and (3) "Glumis glabris, floribus hermaphroditis muticis, femineo aristato, *Holcus halepensis*." The third type is the spontaneous species commonly known in the United States as Johnson grass. In his Mantissa Plantarum (*11*, p. 301) Linné published as a species a fourth type, as follows: "Glumis glabris nigris, feminibus globosis albis aristatis, *Holcus bicolor*."

Forskål (*7*, pp. 174–175) described as species four types, with a varying degree of completeness. One especially, Dochna, he described at some length, including characters of the culm, leaves, and panicle and noting the arrangement of the branches of the latter, as well as the form and color of the sessile and pedicellate spikelets. He also described the caryopsis of this variety as being "the size of rice, oval, compressed, ferruginous, tightly held by the glumes, which have gaping apices."

Arduino (*1*) described six types, called by him species of Holcus, and presented excellent illustrations of the panicles, the fertile and sterile spikelets in one or more stages of development, and in some varieties the caryopsis. He designated certain types as varieties of the so-called species. These differed mainly as to color and form of the seeds or in other minor particulars. His main types, or species, were as follows: (1) *Holcus cafer*, having an abbreviated central axis and which he also states had rounded seeds and small, hairy, easily separated glumes; (2) *Holcus cernuus*, having a recurved panicle with spikelets awned and hairy, glumes ash colored, and seed flattened; (3) *Holcus sorghum*, having an open, spreading panicle, reddish or yellowish seeds which were awned, and indurated glumes not easily separated from the grain; and (4) *Holcus bicolor*, with somewhat verticillate panicles and acute seed grains which exceeded the black and white glumes. Referring to minor types, he states that there were, for example, varieties of *Holcus sorghum* which had seeds shining and red, shining and ferruginous, yellow and glabrous, yellow and hairy, and others reddish; that the seeds varied much in form, being described as rounded and covered, rounded and half bare, and angular; that there were both awned and muticate types; and that there were also varieties which were distinguishable by the height of the stalk, these varying from 3 to about 10 feet.

Körnicke (*9*, pp. 299–315) described 12 types as varieties of *Andropogon sorghum*, grouping them first, according to the forms of the panicle, in two classes, Effusus and Contractus. These two main groups were subdivided, the first according to the length of the rachis and the second as to whether the panicle was erect or recurved. The varieties within these subgroups were separated according to the color of the glumes and the caryopsis and by the form of the panicle.

Hackel (*8*, pp. 499–520) presented descriptions of 36 cultivated types, both sweet and nonsaccharine, as varieties of *Andropogon sorghum*, subspecies *sativus*. He divided the varieties represented in

the material with which he worked into nine groups, according to the form of the fertile and sterile spikelets; the form, color, texture, pubescence, and markings of the glumes; and the length of the pedicel of the sterile spikelets compared with the length of the fertile spikelets, ranging from Group A, in which the fertile spikelet was lanceolate to elliptic-lanceolate and acute, the lower three-fourths of the empty glumes being coriaceous, through groups having spikelets ovate, elliptic, obovate, obovate-rhomboid, deltoid, orbicular, and obtuse-hexagonal. The varieties within these groups were again divided according to the form and other characteristics of the panicle. The sorgo varieties selected for the present study, where conforming at all to his classes, would be included in not more than three or four of them, and only a few of our varieties seem to conform to his descriptions. His characterization of Group C and description of the variety *saccharatus* are here reproduced:

> C. Sessile spikelets elliptic or ovate, twice to less than twice as long as broad, acute or somewhat acute, broadest in the middle or lower down, first glume almost all coriaceous, more rarely in the one-fourth to three-fourths above chartaceous, and there not depressed; second glume acute. Pedicel of the sterile spikelets (rarely male) usually four to five times shorter than the sessile spikelets. Caryopsis equaling or almost equaling the glumes, the mature not exserted.
>
> Var. *saccharatus* (*9*, p. 310), panicle ovate, the lower branches nodding, equaling two-thirds of the panicle; lower branches smooth, for 6 centimeters or 8 centimeters naked. Hermaphrodite spikelets 5.5 millimeters long, 3 millimeters broad, straw color to reddish; sparsely pilose. Caryopsis dilute red. Awn about 10 millimeters long, with bend exserted.

Hackel's description conforms more nearly with our Honey variety than with any other, it being the one commonly cultivated at the present time which has red glumes and the lower panicle branches naked for about 6 or 8 centimeters.

Schumann (*14*) formed the major divisions of his key to varieties cultivated in East Africa on the extent and the manner in which the glumes covered the grain, or caryopsis. He recognized three major groups: Obtectæ, Seminudæ, and Nudæ. The seminaked group was divided into three subgroups according to the degree of compactness of the panicle. His key follows.

Key to the East African cultivated varieties of sorghum, by Schumann

A. Obtectæ. Covered varieties. The glumes are longer than the fruits, closed entirely, or gaping apart at the point only---------- Var. 1, *callomelaena* K. Sch.
B. Seminudæ. Half-naked varieties. The glumes are shorter than the fruit; they lie close to the former, which they far surpass.
  a. Effusæ. Panicles open and spreading, branches of the inflorescence of the first order obliquely erect, overhanging bow shaped at the extremities---------- Var. 2, *elegans* Kcke.
  b. Contractæ. Panicles erect, condensed, the branches of the inflorescence erect and lying close together, more rarely slightly bent outward.
    α. The axis of the panicle gradually attenuate.
      I. Empty glumes black or dark purplish red-- Var. 3, *stuhlmannii* Kcke.
      II. Empty glumes yellowish red---------- Var. 4, *concolor* K. Sch.
    β. The axis of the panicle breaks off suddenly, so that it is far overtopped by the upper inflorescence rays.
      I. Empty glumes yellow---------- Var. 5, *schenckii* Kcke.
      II. Empty glumes brown---------- Var. 6, *baumannii* Kcke.
  c. Compactæ. Panicle recurved, branches of the inflorescence very compact, so that the fruits are crowded together.
    α. Empty glumes black; fruit red---------- Var. 7, *ondongae* Kcke.
    β. Empty glumes black; fruit white---------- Var. 8, *neesii* Kcke.
C. Nudæ. Naked varieties. Glumes as long as the fruit, at the time of maturity expanding, and inflexed from the sides---------- Var. 9, *roxburghii* Hack.

The descriptions which follow this key include, in addition to the points specified, characterizations of the axis and branches regarding form, surface configuration, and pubescence; of the glumes, lemma, and palea in some detail regarding form, size, and pubescence; and of the caryopsis in regard to form, size, color, and markings. It is evident from Schumann's statements in reference to source of material that he worked mainly with dried specimens.

According to Stapf's classification (*16*, pp. 104–154), all his cultivated types, a subgroup in which the mature spikelets persist, belong to a group in which the branches of the first order are divided and the racemes are both terminal and lateral, this being opposed to a second group in which the primary branches are simple and the racemes terminal, and to a third in which these branches are usually solitary, but divided at the base. His main groups of the cultivated forms are established on the texture of the glumes, and the subdivisions of these groups are based on characters of both the panicle itself and the individual spikelets. His key and descriptions include characterizations regarding form and density of the panicle; arrangement, direction, size, and pubescence of the branches; number of joints in the racemes and form and pubescence of the rachises; the form, size, color, nervation, and pubescence of the glumes of the fertile spikelet; and some points in regard to the lemmas, paleæ, caryopses, and the sterile spikelets.

Sorgo varieties in the United States have been described by Wray (*18*), Pech (*12*), Collier (*5*), and Ball (*2*), but Wray's descriptions of types introduced by him from Africa under the supposed African names were not made from the botanical viewpoint, and they give little clue as to which, if any, of the present-day varieties correspond to them.

Pech (*12*) presented descriptions of nine varieties and a key for their identification, employing such characters of the panicle and the seed as the form, size, and habit of the branches of the panicle, the relative length, color, and form of the glumes and grain, and the vestiture of the glumes. But his descriptions were meager, and none of the varieties were known by the names now used; hence it is impossible to identify any of them with certainty as varieties now in cultivation, although each type is represented by a small sketch of both panicle and seed. A reproduction of his key follows.

Artificial key to the varieties of sorgo, by Pech

Ripe seed longer than the glumes ..... LIBERIAN.
Ripe seed equaling or shorter than the glumes.
  Glumes equaling the length of the seed.
    Glumes closed, hiding the seed ..... RED IMPHEE.
    Glumes open, showing the seed.
      Glumes greenish white or ash color ..... WHITE IMPHEE.
      Glumes black or purplish black.
        Branches of the panicle thin; panicle long, widely spreading ..... TRUE CHINESE SORGO.
        Branches of the panicle compact. Panicle short, erect, more or less appressed to the axis.
          Glumes mostly downy ..... EARLY SORGO.
          Glumes mostly smooth ..... OOMSEANA.
  Glumes longer than the seed ..... BLACK IMPHEE.

Ball (*3*) points out that one of these varieties, the Chinese, appears to be similar to some of our strains of Amber. Pech's Red Imphee may have been the Honey or the one known in some localities as

Japanese Ribbon, and his description of Liberian corresponds fairly well with our Sumac, which Collier (*5*) also represents as synonymous. It is impossible to identify the remaining six types with any of the varieties of the present time.

Collier (*5*) amplified Pech's key to some extent and considered 19 varieties in all, but presented few points of distinction not considered by Pech.

Ball's (*2*) key, which was presented for the first time in 1907, employs a considerable number of characters regarding various features of the panicle. It is as follows:

Key to varieties of sorgo, by Ball

A. Peduncle and panicle erect.
  I. Panicle loose, open, branches spreading to horizontal or drooping.
    Rachis two-thirds as long as to equaling the panicle; spikelets usually awned.
      Stems slender; panicle ovate-pyramidal or one-sided; empty glumes deep red or black.
        Empty glumes black.
          Empty glumes rigid, long, more or less hairy, pure black, usually awned--- 1. AMBER.
          Empty glumes longer and thinner, glabrous, usually glaucous when mature, never awned--- 1. MINNESOTA AMBER.
        Empty glumes deep red--- 2. RED AMBER.
      Stems stout; panicle oblong, elongated; empty glumes light brown--- 3. HONEY.
    Rachis less than one-half the length of the panicle.
      Panicle light weight, red-brown, branches 6 to 10 inches long, drooping; glumes with pale margins, acute; seeds deep orange to red--- 4. COLLIER.
      Panicle heavy, pale orange or darker; glumes pale straw color or darker, never all dark; seeds pale orange to deep orange--- 5. PLANTER'S FRIEND.
  II. Panicle close, compact, obovate-oblong or cylindrical; branches appressed or the uppermost spreading.
    Panicle oblanceolate or oblong, 5 to 7 inches long; stems 5 to 7½ feet high.
      Empty glumes about equaling the large seeds.
        Color of panicle pale orange or darker; glumes pale straw color or darker but never all dark, acute; seeds pale orange or darker --- 5. PLANTER'S FRIEND.
        Color of panicle reddish brown or deep brown; glumes red to black, all dark; seeds pale orange to red--- 6. ORANGE.
      Empty glumes about half as long as the small seeds.
        Panicle very compact; glumes black, seeds dark red--- 7. SUMAC.
    Panicle cylindrical, elongated, 10 to 14 inches long; stems 8 to 10 feet high.
      Empty glumes narrow, somewhat shorter than the red seeds--- 8. SAPLING.
AA. Peduncle strongly declined or recurved (goosenecked), or sometimes erect; hence, panicle horizontal, or pendent, or erect.
  Panicle black, ovate or triangular, awned; stems tall and stout, reddened below--- 9. GOOSENECK.

CHARACTERS USEFUL IN CLASSIFYING AND IDENTIFYING TYPES AND VARIETIES

In arranging varieties both for classification and in keys certain authors employ characters which pertain to the form and position of the panicle and of its branches for separating the major groups; others make first use of spikelet characters for this purpose. It is, of course, true that characters which best indicate systematic relationships are not always those most useful for distinguishing the forms, because the differences are sometimes of such a kind that they

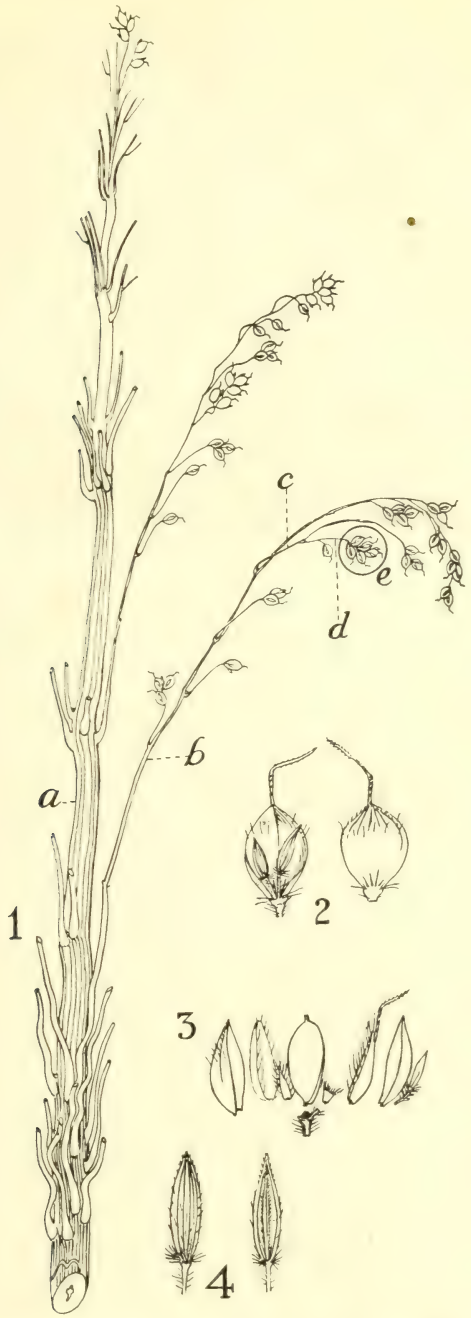
can not be easily measured or described, and because there are frequently transitional forms which prevent the differences being clear cut. Although it is sometimes possible to indicate the variations in the feature occurring in each variety, when such is the case, wide, sharply marked, and constant differences are more valuable for purposes of identification. Characters which may be observed without magnification have greater value than those which must be magnified, and those which are to be seen in all the plants of the variety are of course more dependable than those which occur in only a portion of them. Characters which relate to parts of the plant which are deciduous are never of much value for distinguishing varieties of a cultivated species.

Natural fluctuation occasioned by external influences or other causes often results in an overlapping of characters even when the means are far apart, thus making it difficult to distinguish between the varieties, and when the means are close together the difficulty of discriminating between them on account of such overlapping is of course greater. Although fluctuations are probably due mainly to environmental influences, it should be remembered that there are other causes which may also be effective, as follows: (1) One or more of the varieties concerned may contain a number of biotypes; (2) the ages of the various stalks and panicles in a field always differ somewhat; and (3) the mode of expression of some of the factors concerned is apparently such that they are represented in the progenies alternatively, or in a series of forms, or in varying degrees of intensity. Many morphological features are much modified by causes other than germinal, on which account distinctions based on actual size are usually less reliable than those based on the size character as compared with that of adjacent parts or those based on form. It is to be noted that there are marked differences in the extent to which various features of the sorgo plants are in this way affected by environmental influences, the height of the plant being modified the most, the size of the panicle nearly as much, and the dimensions of the spikelets apparently the least. Since the length of panicle branches arising at various nodes of the axis partly determines its form, fluctuations in form are in some cases ascribable to the fact that the panicle branches on the upper part of the axis develop a little before those on the lower part, soil or climatic conditions being somewhat different at the two periods.

DESCRIPTION OF PLANT

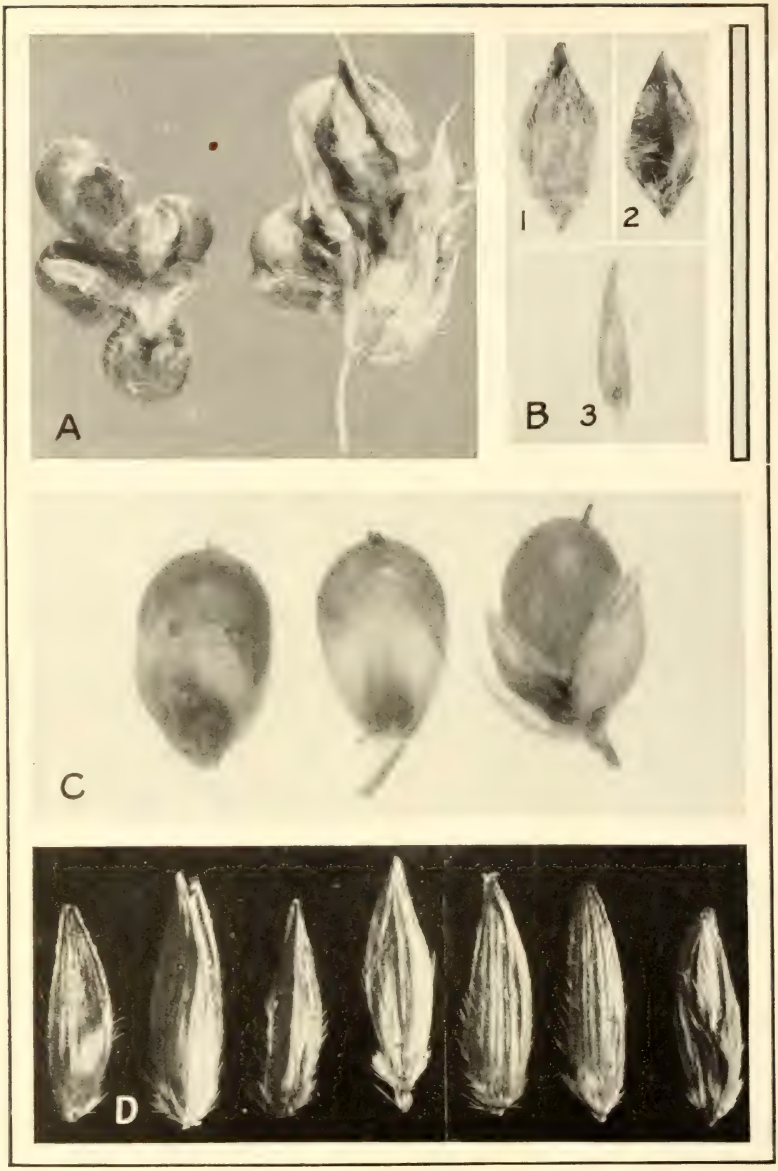
VEGETATIVE PORTION

The sorghum plant, whether belonging to the sorgo or the nonsaccharine group, consists essentially of one or more culms, or stalks, having pithy interiors and arising from the root system. Each culm is composed of a series of internodes which decrease in diameter from the base of the stalk upward. As in other species of the Gramineæ, a bud and a leaf, the latter consisting of a sheath and a blade, originate at each node. The sheaths in this group of sorghums for the most part completely cover the internodes above, although there are a few varieties in which some of the sheaths



HONEY SORGO (SUGAR PLANT NO. 0241466)

1, Axis of panicle, primary and secondary branches, racemes, and spikelets; 2, fertile spikelet with sterile spikelets attached; 3, fertile spikelet dissected and sterile spikelet, showing part of rachis segment, the glumes, sterile lemma, fertile lemma with awn, the palea, lodicules, and caryopsis of the fertile spikelet; 4, sterile spikelet, showing pubescence of the pedicel and callus, the scabrous-hispid lateral nerves, and ciliate edges of the first glume



SPIKELETS AND GLUMES OF SORGO VARIETIES

A, Arrangement of fertile and sterile spikelets in racemes in two varieties: Sumac (Sugar Plant No. 0181) and Planter (Sugar Plant No. 01816). × 3. *B*, First glume (1), second glume (2), and sterile spikelet (3) of Planter (Sugar Plant No. 01816); pubescence of first glume persistent, that of the second semideciduous. × 4. *C*, Caryopsis much exserted; Sumac (Sugar Plant No. 0181). × 6. *D*, Conformation, venation, and pubescence of sterile spikelets of the Gooseneck variety (Sugar Plant No. 021612–17). × 6

HONEY SORGO (SUGAR PLANT NO. 0241466), A VARIETY OF THE EFFUSE TYPE

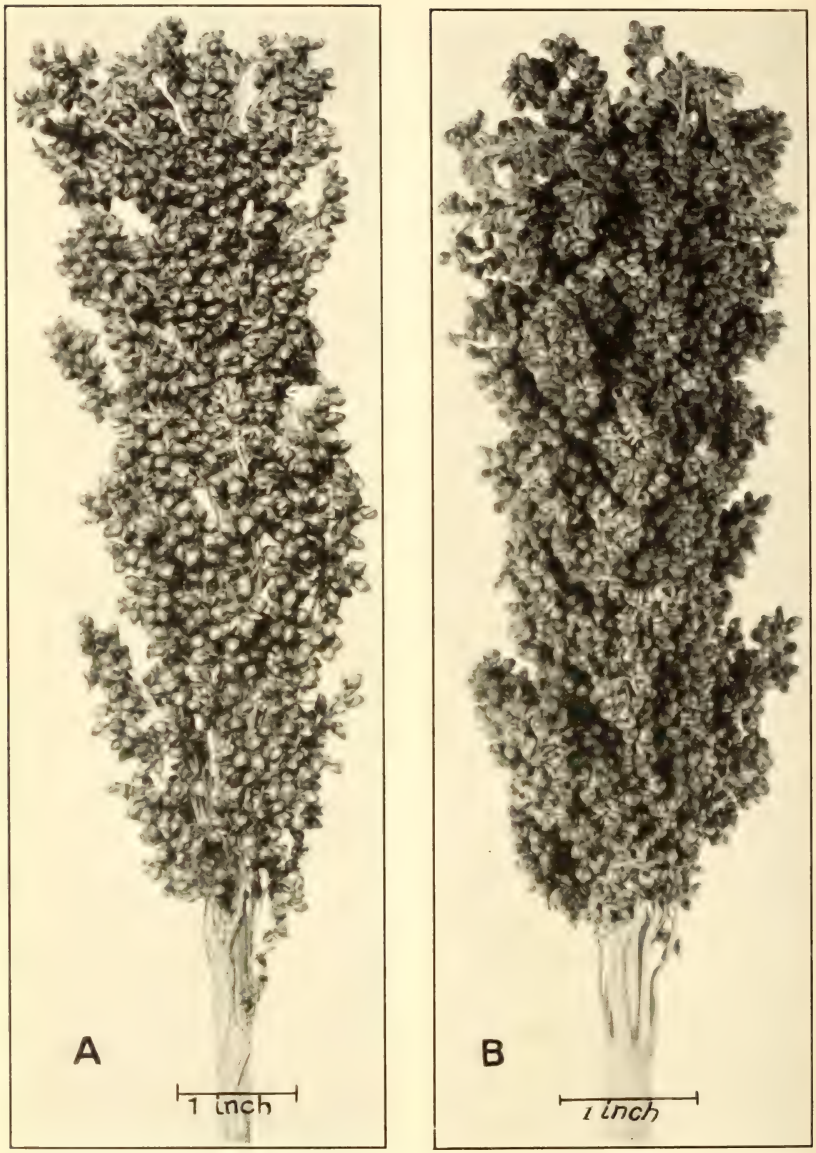
COLLIER SORGO (SUGAR PLANT NO. 01960), A VARIETY HAVING THE AXIS OF THE PANICLE OFTEN MUCH ABBREVIATED

Two panicles are shown. In one the axis is continued to the apex, in the other it is reduced to less than one-fourth the length of the panicle

McLEAN SORGO (SUGAR PLANT NO. 0182), A VARIETY OF THE SPREADING-CYLINDRIC TYPE

COLMAN SORGO (SUGAR PLANT NO. 021598 603), A VARIETY IN THE CONTRACTED GROUP

ORANGE SORGO (SUGAR PLANT NO. 01959), ONE OF THE VARIETIES IN THE CONTRACTED GROUP



TWO SORGOS OF THE COMPACT-CYLINDRIC TYPE

A, Sugar Drip sorgo (Sugar Plant No. 021624–29); *B*, Sumac sorgo (Sugar Plant No. 0181)

fail to reach the next node. Certain varieties always produce branches from some of the upper buds, but other kinds branch only when the plants are approaching maturity, usually as an effect of abundant precipitation after a period of drought. Under normal conditions the main culm as well as each branch is terminated by a compound inflorescence, a panicle which emerges from the sheath of the last leaf, the accompanying blade of this sheath being considerably shorter than the blades of the other leaves. The panicle is joined to the last node of the culm or branch by a specialized internode, the peduncle.

THE INFLORESCENCE

Panicles on initial culms and those on branches are similar except that they may differ in size, climatic and soil conditions which affect the general growth of the plant also much modifying the development of the panicles. When conditions are favorable during the period of development of the panicles, those on the initial culms are large, but if conditions are unfavorable during those periods they remain small, or they even may not emerge, and the panicles which surmount branches, which are usually put forth subsequently from some of the upper buds of the culms after conditions have become more favorable, often surpass in size those on the initial culms.

The central axis of the panicle is divided into internodes, at the nodes arising primary branches, or rays. The internodes are frequently so short that the nodes are very close together, and the rays then have the appearance of being in part in whorls. There are usually, however, rays interspersed between the apparent verticils. Rays which originate at the nodes of the axis rebranch, and branches of the third rank also occur. The arrangement of branches on the axis in a variety of the spreading type, the Honey (Sugar Plant No. 0241466), is shown in Plate I.

Racemes having from one to five joints occur at the ends of the branches. Racemes of two varieties, Sumac (Sugar Plant No. 0181) and Planter (Sugar Plant No. 01816), are shown in Plate II, A. The rachises of the racemes in this group of sorghums do not disarticulate at the joints. They are hairy in all our varieties. Spikelets, which are secondary inflorescences, occur in pairs at the joints of the rachis, one fertile and sessile and the other sterile and usually pedicellate, except that at the last joint two sterile spikelets occur in union with a single sessile fertile spikelet. In most of the varieties the sterile spikelets fall off to a great extent before or soon after the fertile spikelets become mature. They do not disarticulate from their pedicels, however, nor do the pedicels disarticulate at their bases; but the latter become dry and rupture at some point, whereby the sterile spikelets become free and drop off abundantly.

The fertile spikelet consists of a short floral axis on which the following parts, or members, occur in a 2-ranked arrangement: The first glume, the second glume, a sterile floret, and a fertile floret. The glumes, or outer bracts, are usually somewhat indurate and more or less thickened. Before anthesis the first glume partly incloses the second, and the glumes together completely cover the other members. In some varieties also in the mature state the glumes constitute the most conspicuous parts of the spikelet, but in others they are

relatively smaller than the caryopsis and are less conspicuous. The sterile floret consists of a lemma only. When it is present in the mature spikelet it is to be found between the first glume and the caryopsis, or grain. It is known sometimes to produce a caryopsis, but in no variety examined does this occur except very rarely and in single spikelets. The fertile floret consists normally of a lemma, a palea, two lodicules, an androecium of three stamens, and a 1-celled ovary, or carpel, the latter bearing two styles, each of which is surmounted by a papillose stigma. With the maturing of the spikelet, the stamens and the stigmas together with their styles wither and drop off; and after fecundation the carpel with its inclosed ovule becomes the caryopsis, or grain. The lemma lies between the second glume and the caryopsis in the mature state, and the palea between the sterile lemma and the caryopsis. Both these members are hyaline and delicate, and when they remain intact in the mature spikelet they are usually so hidden by the much-thickened glumes that they are of little value for purposes of varietal differentiation. The awn when it is present is attached to the lemma of the fertile floret. The two minute lodicules lie opposite to the palea, and they are therefore to be found adjacent to the fertile lemma at the base of the spikelet. In our varieties the glumes open more or less widely, and in many of them the caryopsis becomes partly exserted.

The caryopsis varies considerably in form, but it is always thicker laterally than dorsoventrally. Its hilum is small but is distinguishable without magnification, being at the base of the caryopsis on the ventral side, this being the side next to the first glume. The embryo with its rather large scutellum is visible on the opposite, or dorsal, side. As in other grasses, the hilum lies adjacent to the palea and the scutellum adjacent to the fertile lemma. The bases of the two styles usually remain at the summit of the mature caryopsis.

The sterile spikelet is more elongate than the fertile one, and its glumes are herbaceous. These spikelets vary somewhat as to parts represented, the differences being indicated in a subsequent paragraph.

CHARACTERS OF THE VEGETATIVE PARTS

Differences in some morphological features of the vegetative portion of the plant, as distinguished from the panicle, or inflorescence, are genetically transmitted and would therefore constitute varietal characters of greater or less value. The chief of these are the diameter, taper, and color of the culms; the number and form of the internodes; the size of the nodes; the extent of branching; the length, width, and direction of the leaves; the amount of overlapping of the leaf sheaths; and the length and manner of opening of the last leaf sheath, or boot.

CHARACTERS OF THE PANICLE

The manner of emergence of the panicle presents several variations, some of which are more or less striking. The period of emergence extends over only a few days, however, and for this reason the characteristic has little value for purposes of differentiation or classification.

THE PEDUNCLE

There are two types of peduncle in regard to form, the straight and the recurved. Various degrees of curving are always in evidence in the variety, and there are always panicles having uncurved peduncles, as was indicated by Ball (*2*). The number curved is frequently only a small proportion of the entire number in the field. Evidently a relation exists between soil or seasonal conditions and the amount of recurving. Populations of which the original source of seed was the same, when grown in different plats and in different seasons, have shown diversity in the number of recurved panicles present. This lessens the value of the feature. It is nevertheless useful, as it is very obvious when it occurs, and it has been employed by nearly all writers.

Peduncles also show differences along varietal lines in regard to length. They originate at the last node of the culm where the last leaf sheath or boot, which covers them to a greater or less extent, also originates. As the boot also varies in length, the peduncle may be of considerable length but have the appearance of being short on account of the length of the boot. Fairly well-marked differences are to be seen between varieties both in length of the peduncle and the extent to which it is exposed. Although the extent of exposure has the disadvantage of being somewhat influenced by climatic conditions, it is dependent upon the relative length of adjacent parts that develop at about the same time and is therefore adaptable, especially when varieties are chiefly determined in the field.

CONTRASTED PANICLE CHARACTERS

The most striking contrasts exhibited by panicles are: (1) Varying degrees of compactness, resulting from variation in the length of the axis and its branches and in the length of the internodes of both, and (2) variations in form. Various types of panicle are shown in Plates III to VIII, their relative size being indicated by the 1-inch scale in the illustrations cited. In the most spreading types, when the seeds have reached complete development both the axis and branches are relatively long, the branches of all ranks are well separated, stand out more or less from the axis, are bowed, and are occasionally pendent at the extremities. On the other hand, in the compact types, which are at the other extreme, all these characters are reversed, the axis and the branches, as well as their internodes, being shortened, the branches being somewhat rigid and cleaving more or less to the axis, and the seeds being crowded together. Between the two contrasting types there are types intermediate in regard to degree of compactness. Although much heterogeneity exists among these, the branches in all are more or less shortened, and they may be considered together under the head of the contracted class. All types are subject to fluctuation, and all also undergo progressive natural changes which alter the apparent degree of compactness from the time the panicle first emerges until after the seeds are mature. These alterations are especially noticeable in the more effuse types, being due in part to a natural tendency of expansion in the panicle and in part to climatic influences. Pulvini occur in the axils of the branches, though they are better developed in the spread-

ing types of panicle than in the more compact types. Under moist conditions these pulvini become turgid, causing the branches to expand, and the panicle thus tends to open; but in periods of dryness the pulvini tend to lose some of their turgidity and to contract, the branches then closing up to a greater or less extent. Continued humidity, moreover, has a further effect on the panicle, especially after it has reached approximate maturity, the branches then all becoming permanently more or less bowed and the pulvini losing much of their power of expansion and contraction after the panicle reaches maturity. As a result of these conditions all the branches tend permanently to stand out somewhat from the axis. For these reasons no sharp lines of distinction can be drawn between the spreading and the compact or between the spreading, semicompact, and compact types of panicle.

In a general way certain distinct forms of panicle are also recognizable, these being mainly due to variations in the length of the axis and in the length of the branches originating at different points in this length. By considering form and degree of compactness together certain rather more definite types are recognizable, as follows: (1) The spreading conical, (2) the semicompact conical, (3) the semicompact cylindric, (4) the compact oval, and (5) the compact cylindric. When, however, it is attempted to use these types of panicle as varietal characters, difficulties are sometimes encountered, as the variations within varieties, fluctuations, and changes which take place during the period of anthesis and subsequently often alter the form; but the relative length of the axis and the branches and the length of branches originating at different points may both be taken as in part indicative of the form and so may help to establish the type, as these characters do not change materially after the spikelets have all reached complete anthesis. In the typical conical spreading form the primary branches or rays originating at the base of the panicle are the longest, being usually two-thirds or three-fourths as long as the panicle itself, and those originating at points higher up being successively shorter. In the cylindric form, which is at the other extreme, the primary branches are more nearly equal in length, none of them usually exceeding half the length of the panicle. In certain varieties which have a cylindric form of panicle, however, the lower primary branches in some of the panicles are considerably longer than those originating above them and have a tendency to be appressed to the axis; and these panicles on this account, although they are cylindric, do not differ from those of certain varieties in an intermediate class in relative length of the branches originating successively on the axis.

The length of the internodes of the axis and of the branches and the comparative rigidity of the branches both indicate to a certain extent the type of panicle. Rigidity is, however, somewhat dependent upon length, branches showing the greatest rigidity not being relatively thicker, as compared with others, so much as they are relatively shorter, rigidity also being much subject to fluctuation and somewhat dependent on state of maturity. It is sometimes not possible, therefore, to note differences in this characteristic between the panicle branches of certain varieties which are properly classed in separate groups. In the same way the length of the internodes

of the axis and of those of the branches of the inflorescence are variable, this variability resulting largely from environmental influences, so that neither is of much value if employed alone unless the varieties happen to have been grown under the same conditions of soil and climate. Often, for these reasons, it is only when all the characters mentioned are considered together along with certain minor features which are discussed in subsequent paragraphs that a conception of the type of the panicle can be accurately obtained. Contrasts in panicle type are, however, very evident between certain sorts and are outstanding characters, varieties often being more easily distinguished by such differences in the panicle than by any others, such differences also being the ones most commonly employed by growers in distinguishing one sort from another.

LENGTH, FURROWING, AND COLOR OF THE AXIS

The length of the axis as compared with the length of the panicle shows considerable variation. It may extend to the summit of the panicle or it may be reduced to shorter lengths. It is sometimes so shortened that there is but one whorl of primary rays. When it is elongated it is attenuate and when abbreviated it is usually truncate. The effect of shortening the axis on the form of the panicle is usually to make it roughly obovate or obconical. In these forms the upper branches are usually as long as or longer than those originating at the base.

Varieties differ in regard to length of axis, in some of them the character being partly concealed by rigidity of the branches; within the varieties also there is usually considerable variation among the panicles in regard to axis length. In certain varieties the axis is rarely less than three-fourths as long as the panicle. In certain others it is frequently somewhat shorter. In still others it is often much shorter; it may be reduced to a single node and it may vary from this until it equals the entire length of the panicle. No variety of sorgo has been examined in which all axes were greatly reduced, that is to say, to less than about one-fourth the panicle length. Among the varieties examined, however, three show it frequently so, and in each of these, axes of various greater lengths also sometimes occur. In one variety of sorgo, axes of several lengths are sometimes seen on the main culm and branches of the same plant. Two panicles of one of the varieties showing this characteristic are represented in Plate IV, in one of them the axis being elongated and in the other much abbreviated.

This feature has been employed in keys and descriptions by a number of writers describing sorghums, including Forskål (*7*, pp. 174–175), Arduino (*1*), Körnicke (*9*, pp. 294–315), Schumann (*14*), and Ball (*2*), which shows that at various times it has appeared as an outstanding character. The fact that in all sorgo varieties in which it occurs panicles also are to be seen in which the axes are prolonged emphasizes the need of examining varieties at least in part in the field, and not depending solely on a small number of dried specimens.

Lines which have been self-fertilized for a number of years have shown variation in axis length within progenies resulting from single self-fertilized panicles. It therefore seems evident that the mode of

expression of the factor which controls the character is of such a nature that the latter may be expressed either in the elongated or the abbreviated type and that intermediate steps may also be present. Although panicles on branches are likely to have relatively longer axes than those on initial stalks, this is not always the case, examples occurring in the self-fertilized lines in which the reverse is found. It is to be noted also that in certain years more of one or the other of the extreme types has been in evidence, and although observations have not been carried far enough to warrant definite conclusions it seems probable that environmental conditions influence the relative length in panicles both on initial stalks and on branches.

Varieties show differences in the number and arrangement of branches on the axis, its depth of furrowing, color, and pubescence; and in the contracted and compact types and also occasionally in the spreading types there are frequently one or more nodes at the base of the panicle without branches. The presence of furrows is believed by Schumann (*14*) to be due to the pressure of branches against the axis in the early stages of development. In certain varieties the furrows are shallow and in others they are deeper, although the differences are never very wide. The axis often has a tint resembling the color of the glumes of the fertile spikelet more or less modified, but more commonly the color is similar to that of the peduncle.

PUBESCENCE OF THE AXIS

Three distinct conditions of pubescence occur on the axis: (1) Fine pilosity, sometimes much appressed, occurring either more or less uniformly over the surface or mainly in the furrows; (2) hairiness on the ridges, longer than the latter and more or less forming a fringe; and (3) a scabrous-hispid condition on the ridges. These three types are shown in Plate IX, A, B, and C. Conditions more or less intermediate between these are encountered also. All varieties are found to be hairy at the nodes, but some are much more hairy than others. A fourth condition, which, however, is less distinct as it usually blends into the first, is a somewhat tufted or barbate condition at the nodes. Certain kinds are essentially glabrous except for hairiness at the nodes and fine bristles or teeth on the ridges, and others are hairy throughout, the axis as a rule being more pubescent in the more compact types of panicles and less so in the effuse types. In certain varieties where the nodes are well separated the spaces between are glabrous or nearly so, and where they are close together they are hairy.

BRANCHES OF THE PANICLES

The actual differences in the length of branches of all ranks arising at the same relative positions in the panicle are considerable in extreme types, the relative length of branches in four types being shown in Plate X. Their length, however, is much subject to modification by influences other than germinal. Differences in length are therefore never of more than secondary importance as varietal characters, and as would be assumed, in intermediate types no lines of separation are possible, length being always so variable

that no definite values can be assigned to any variety. The approximate length of primary branches as compared with the length of the panicle itself is in a measure adaptable, its relation to the form of the panicle having already been noted.

The primary branches or rays from the lower nodes of the axis are more or less devious, and in one variety they are somewhat spirally twisted. The primary, secondary, and ultimate branches are somewhat angular in some varieties, though not in others; this difference is then distinctive. As a rule, branches in the effuse types are less angular than those in the more compact types. As in the case of the axis, the branches in certain varieties are sometimes tinted, the color resembling that of the glumes of the fertile spikelets, though in others such coloration is not evident or is very much less marked, this also being true of the rachises of the racemes.

PUBESCENCE OF THE BRANCHES

In certain varieties the pubescence on the primary and secondary branches is limited mainly to hairs on their bases and in the axils, and to fine hairs, bristles, or teeth fringing the ridges. In others these branches are more or less hairy throughout. In certain varieties also the pubescence is uniform or mainly so in the striations, and in others the hairs on the angles are longer or more abundant. The axils may be somewhat barbate or pilose, this pubescence sometimes also extending over the flattened surface of the branch adjacent to the axis and sometimes to the angles as somewhat longer hairs. The ultimate branches present three distinct types regarding pubescence: (1) The ciliate on the angles or ridges, (2) the scabrous, and (3) the glabrate.

THE FERTILE SPIKELET

The fertile spikelet exhibits greater differentiation than the panicle itself, as such, or the axis or branches of the panicle, the differences relating to the form and size of the spikelets; the form, texture, thickness, nervation, pubescence, color, markings, and manner and extent of opening of the glumes; the presence or absence of the awn; the form, color, and comparative size of the caryopsis; and variations in some of the features of the caryopsis. The awn, as well as some of the other features of the spikelet, is present at an early stage, even before the panicle emerges from the sheath. Investigation of the spikelet is much facilitated if it is magnified, a reading glass or hand lens enlarging to two or four diameters being adequate for observing the form, although it is desirable to have greater magnification for the purpose of examining the spikelets in regard to nervation and pubescence. A binocular dissecting microscope has been found serviceable for these purposes in the laboratory, but a hand lens of good quality, enlarging to about 8 diameters, may also be successfully used. Such a lens has the advantage of being easily transported and is therefore better adapted to field use. The smallness of these spikelets, making magnification necessary in order to study them properly, somewhat lessens their value for purposes of identification. On the other hand, the large number of their features

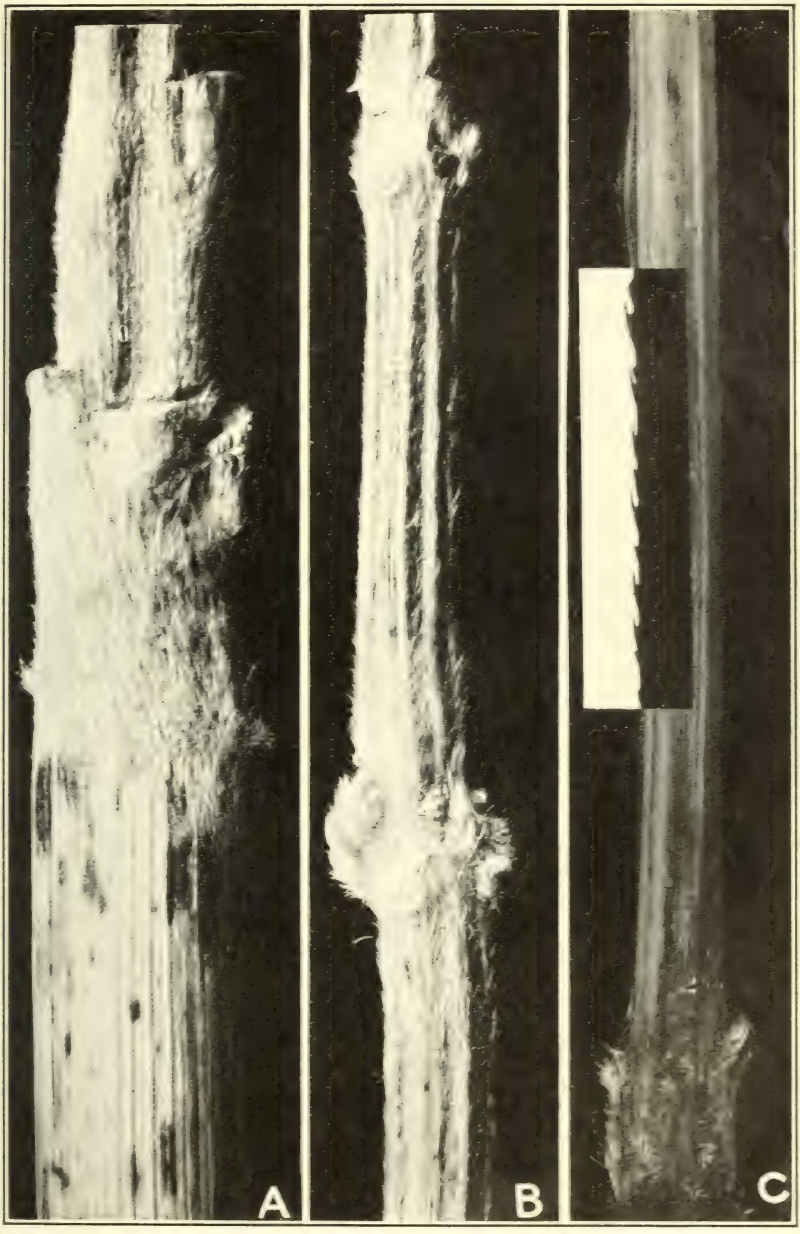
showing differentiation, in many cases very pronounced, make them of value. The fact that each panicle contains a number of spikelets also makes it possible to substantiate the characters with much certainty. Hackel (*8*, pp. 499–520) made use of form of spikelet and texture of the glumes as major characters for distinguishing his groups; Pech (*12*) and Collier (*5*) employed certain spikelet characters in their keys, particularly the relative length of the glumes and caryopsis, which they used as means of separating major classes; Ball (*2*) also employed certain spikelet characters in distinguishing between groups and between varieties.

SIZE OF THE SPIKELETS

The length of the spikelets in varieties examined ranges from 0.1 to 0.25 inch. There is much less variation in size within panicles and within varieties than there is in the length of branches of the panicle of either primary or secondary rank, the average length in the variety which has the shortest spikelets being approximately 0.12 inch and approximately 0.22 inch in the one in which the spikelet length is greatest, these varieties each showing the same ranges of spikelet lengths and the same average lengths in spikelets for the years 1920, 1922, and 1923, in which this character was examined. Although their size is possibly sometimes slightly affected by environmental influences, it is without doubt always less so than is that of the panicle itself or its branches. Because differences between some varieties are very large, the character is useful. The relative length of glumes and caryopsis is discussed in a subsequent paragraph.

FORM OF THE SPIKELETS

In regard to form, the spikelets of the varieties in general may be considered as belonging to one of three groups—the ovate, the elliptic, or the obovate, these terms referring to the outline of the spikelet as viewed dorsally or upon the dorsal surface of one of the glumes, not taking into consideration the caryopsis, which is frequently more or less exserted from the glumes. Although the first glume is inserted below the second and commonly is partially wrapped around it even in the mature panicle, the outline presented by the two glumes is usually approximately the same. Occasionally, however, there is a slight difference, and the first glume usually best indicates the form of the spikelet. Its outline, being somewhat larger than that of the second, usually forms the outline of the spikelet. The terms "ovate," "elliptic," and "obovate" are used in a general sense to indicate forms whose greatest breadth is below the middle points in its length, at the middle, and above the middle, respectively. These three primary forms of spikelet are shown in Plate XI and Plate XII, C. In a restricted sense these terms, of course, have a more definite meaning. There are also intermediate forms and fluctuations are often such that forms more or less intermediate occur in the same panicles with those more distinct and more definitely recognizable. In making a key for identification, however, varieties may be classified in one of the above groups by taking



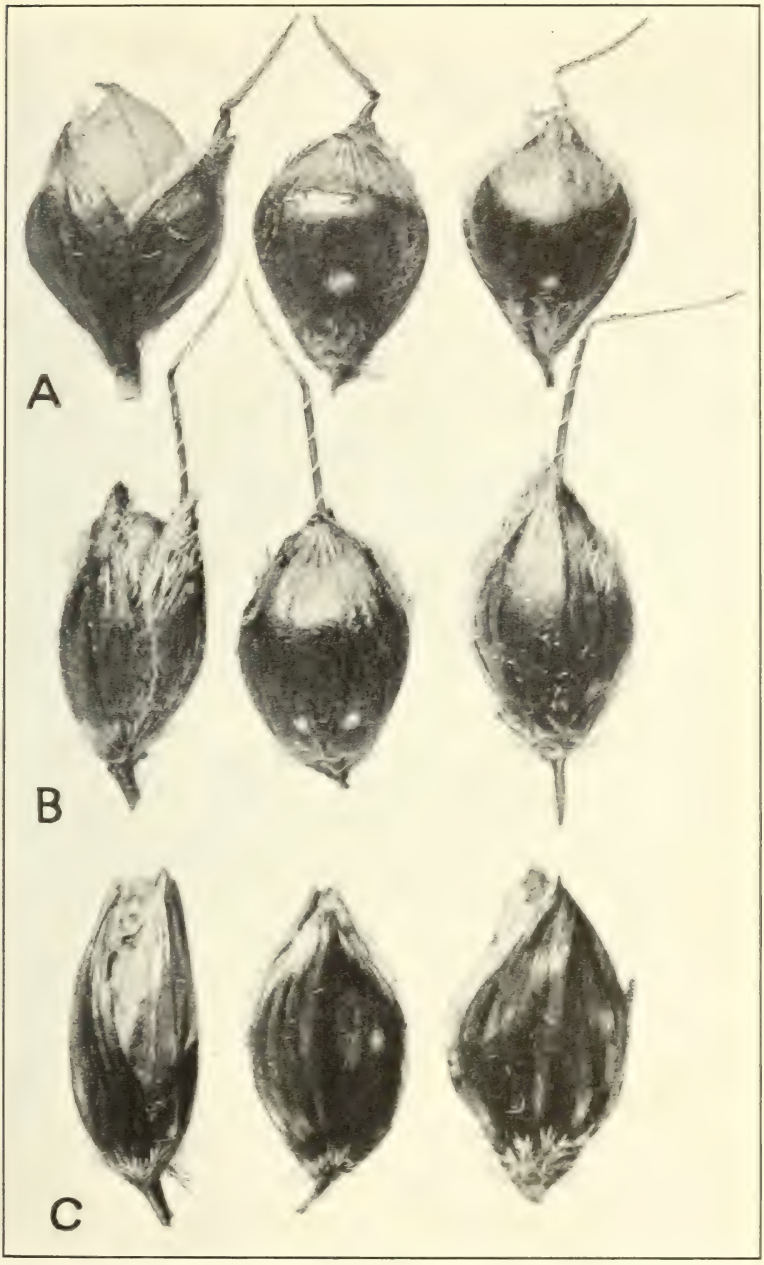
THREE TYPES OF PUBESCENCE ON THE AXIS OF THE PANICLES OF SORGO

× 7; the insert in *C* is about × 25.

A, Planter (Sugar Plant No. 01816); uniform pilosity. *B*, Sapling (Sugar Plant No. 021630-31); more or less pilose and also showing cilia on the ridges. *C*, Minnesota Amber (Sugar Plant No. 021116); the nodes pilose and somewhat barbate and the ridges scabrous.

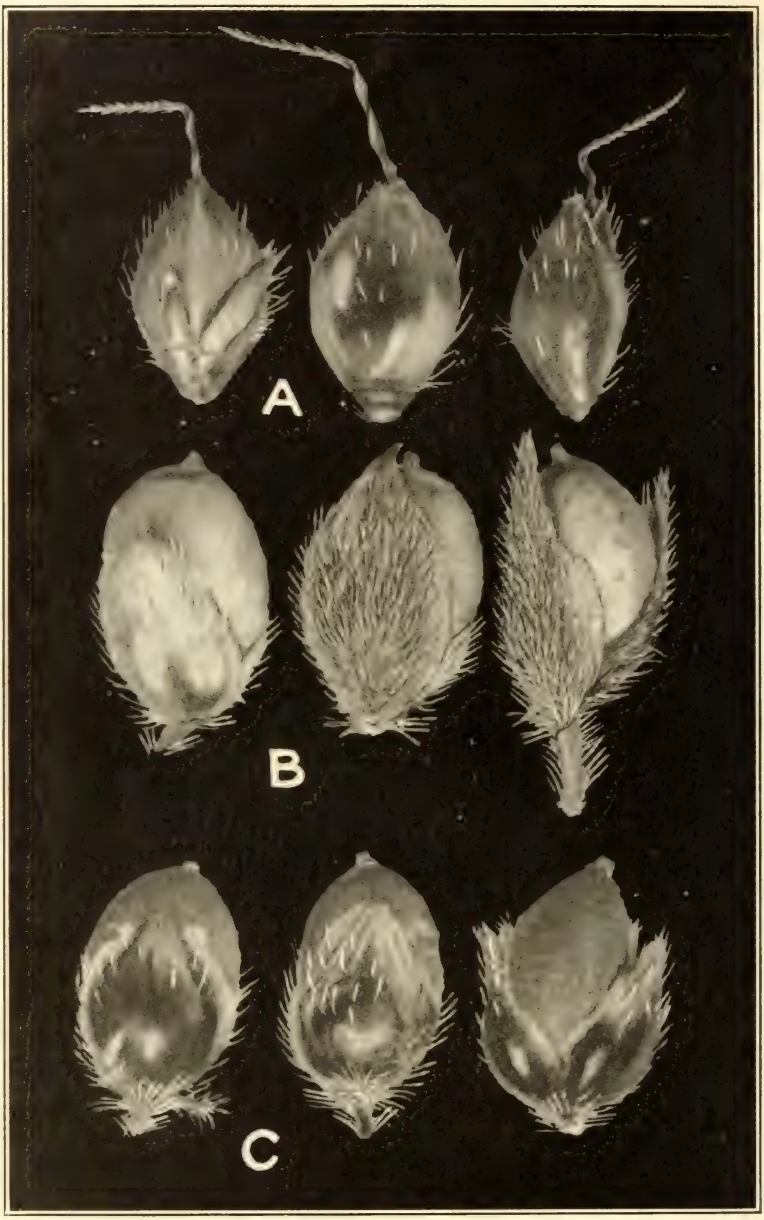
RELATIVE LENGTH OF PANICLE BRANCHES OF SORGO

Four types are shown, from left to right as follows (slightly reduced): Sumac (Sugar Plant No. 0181), Orange (Sugar Plant No. 01959), Planter (Sugar Plant No. 01816), and Honey (Sugar Plant No. 0241466)



FERTILE SPIKELETS OF THREE VARIETIES OF SORGO.—1. × 8

A, Indiana Amber (Sugar Plant No. 021697–702); obovate spikelets; glumes much thickened; caryopsis somewhat exserted; awn short, loosely twisted. *B*, Sasnac Amber (Sugar Plant No. 01958); elliptic spikelets; glumes less thickened; caryopsis not extending as far as glumes; awn long, closely twisted. *C*, Minnesota Amber (Sugar Plant No. 0231115); elliptic spikelets; glumes thickened only slightly at the base; awnless; caryopsis not extending as far as the glumes



FERTILE SPIKELETS OF THREE VARIETIES OF SORGO.—II. ×8

A, Honey (Sugar Plant No. 0241466); elliptic and obovate-elliptic spikelets; pubescence semideciduous; awn somewhat loosely twisted; caryopsis not extending as far as the glumes. *B*, Planter (Sugar Plant No. 01816); ovate-elliptic spikelets; pubescence more persistent except where the glumes are considerably indurate; caryopsis extending as far as the apices of the glumes. *C*, Silvertop (Sugar Plant No. 021618–23); elliptic-ovate and ovate spikelets; pubescence semideciduous except on the callus, where the hairs are somewhat longer and more persistent; caryopsis extending beyond the apices of the glumes

either the prevailing or the average form as the typical one, or one of the groups may be so defined as to include a range of forms rather wider than the other groups.

It is often necessary in order to distinguish between certain varieties to know in some detail how they differ, and this can best be shown by describing them completely and indicating the forms of spikelet which each variety presents. On account of such fluctuations in form, it is, of course, always desirable in making determinations to examine an entire panicle, or, better, several panicles of the variety, in order to be sure of the forms represented.

All ovate forms are not identical; neither are all the obovate forms. Such terms do not therefore indicate very definite shapes. Hackel (*8*, pp. 499–520) made these terms more definite by indicating the point in the length at which the breadth was greatest. It is also possible to describe more accurately intermediate forms by making distinctions between such compound terms as ovate-elliptic and elliptic-ovate, the former being considered a shape more elliptic than the latter, being an elliptic shape occasionally or somewhat ovate, and in like manner the latter being considered a nearly ovate but somewhat elliptic shape.

The form of the spikelets in the unexpanded panicle and also before the caryopses develop to such size as to cause the glumes to spread, or before they become exerted from the glumes, differs more or less from their form in the mature panicle. The enlarging caryopsis tends to make the spikelet broader and in some cases to make it more obovate. The opening of the glumes, on the other hand, tends to make the outline more ovate in form, because one of them is often folded back in the process of opening.

Spikelets of the several varieties occasionally show slight differences in thickness and in their form laterally, both these characters being much influenced by the extent to which the glumes open. They are relatively less important than the foregoing characters. The form of the apex differs also. Most commonly it is acute, but in some varieties it is obtuse, and in others occasionally it is somewhat acuminate.

FORM OF THE GLUMES

The outline presented by the glumes viewed dorsally is usually similar to that of the spikelet, and the range of forms in glumes is therefore approximately the same as in spikelets. From a lateral view the glumes are usually either convex or boat shaped, but the first is sometimes somewhat flattened. In some varieties the lower two-thirds or three-fourths of the first glume is convex, and the portion adjacent to the apex is somewhat flattened, and in those kinds in which the glumes are strongly obovate the upper portion is often very convex and the lower less so. The second glume is commonly more or less keeled, and the first usually has a coarse or keellike nerve on each side, this tending to alter the form more or less, according to its coarseness and prominence. One or both glumes are frequently longitudinally wrinkled or puckered at the base.

Both glumes are usually either inflexed or incurved on the side, the degree varying somewhat. As the spikelet opens, the glumes

retain approximately their original forms except that their margins flatten out against the caryopsis. The characteristic mentioned by Schumann (*14*), that of involute glumes, although not common in any of the varieties studied by the writer, sometimes occurs in one variety.[3] In certain of these varieties also the margins are strongly infolded at the apices.

As in the case of the spikelets, glumes may be acute, obtuse, or acuminate, and in some varieties also the first glume is often toothed at the extremities of the keellike nerves.

THICKNESS AND TEXTURE OF THE GLUMES

In all varieties of sorgo at least one glume is always somewhat hardened, and in most of them both are considerably thickened, the thickening usually being greatest at the base and decreasing toward the summit and the margins. The margins, too, are usually somewhat hardened, and in some varieties they are somewhat thickened, but their outer borders are always thin. Frequently they are hyaline and so delicate that they almost or entirely disappear by the time the seeds are mature. The degree of thickening at the base is more or less proportional to the extent thickened toward the summit. Differences in hardness and in thickness are easily detectable when spikelets are dissected, there being four or five stages or degrees of thickness somewhat definitely recognizable in the varieties that have been investigated.

The distance from the apex downward that the glumes will permit folding without breaking is used as a partial test for the extent of hardening. In some types, however, the glumes are entirely brittle, lacking pliability even at the apices, and in such cases their appearance at the apices, in the margins, and when crushed may be used as a partial indication of the relative amount of hardening that obtains. The amount of both hardening and thickening is also indicated in a general way by the length of the nerves from the apex downward, this feature being considered further in a subsequent paragraph on venation.

The amount of thickening is never easily indicated, as there is no way of distinguishing between different degrees. In the variety represented in Plate XI, C, the second glume is hardly thickened at all, and the first is thickened below only. The variety shown at A represents the other extreme, the glumes being somewhat thickened even at the apices and in the margins. Although such differences are manifest between certain varieties, being plainly discernible with a slight magnification, they can not be readily measured or adequately shown by means of photographs; and although such variations in thickening very evidently indicate relationships between certain forms, the character is manifestly not a good one for purposes of identification.

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[3] Occasionally lateral pressure exerted by the glumes on the caryopsis, resulting from the glumes becoming strongly incurved on the sides, has the effect, mentioned by Schumann, of causing the caryopsis to rotate in the spikelet. This is seen more frequently in herbarium specimens than in panicles in the field, and it is doubtful whether it ever occurs in the varieties studied except when the grains are dislodged by handling the panicles or possibly in the field from agitation by wind.

EXTENT AND MANNER OF SPIKELET OPENING

Spikelets tend to open to definite angles, which vary with the variety, the extent of opening being determined mainly by the size of the caryopses as compared with the glumes, the former together with the lodicules as they increase in size tending to force the glumes open. Although some differences exist between spikelets within varieties as well as between those within single panicles, climatic and probably also soil conditions modifying development of the caryopsis somewhat, the tendency is for spikelets of each kind to be spread on the average about the same each year. The fluctuation due to weather conditions apparently depends much upon the time that radical climatic changes occur, and as all the spikelets of a variety do not develop at the same time there may not, for this reason, be absolute uniformity in the amount that spikelets open even in the same panicle. This must be taken into consideration in estimating the normal amount. Both the means and ranges of angles assumed help to characterize certain varietal groups and also certain varieties themselves. Marked variation from the width of opening commonly seen in a form may usually be considered as denoting an impurity, this frequently being due to chance hybridization with another type.

It was found better to measure the angle made by imaginary lines drawn from the points of insertion to the apices rather than the angle made by the edges of the glumes, as in some forms the edges are more or less curved, and in those which open but slightly the angle made by the edges is relatively too large, as compared with those which open wider. The range of average angles in the varieties studied extends from about 10° or 15° to about 70° or 80°. In none of these varieties are the glumes always closed. Pech (*12*) and Collier (*5*) both based groups on whether the glumes were open or closed.

The manner of opening also varies considerably with the different varieties, being due in part to the relative thickness of the first and second glumes at the base, in part to the relative positions of the two glumes, in part to their form, and in part to differences in the manner in which the caryopsis develops. In certain varieties in which the glumes are considerably thickened at the base both glumes yield about equally to the pressure exerted by the caryopsis as it increases in size, and even though the glumes open as much as 45° there is no bending back of either one of them, but because of their thickness at the base they pivot at their points of insertion. In certain other forms one or occasionally both glumes are either bent or folded back at a point somewhat above the insertion. When one glume yields more than the other the first is commonly the one mainly forced back, as it is inserted below the second and is outside of it. Usually it bends at a point just above the callus and may be sharply doubled, so that a fold or crease is formed. In certain other varieties in which thickening is somewhat less than in those thus bent both glumes are sometimes slightly bent or creased, both yielding easily to the pressure exerted from within. There are, moreover,

varieties in which the second glume is bent more than the first, this resulting from the caryopsis developing more in that direction than the other.

VENATION

The first glume is commonly more strongly nerved than the second, and in the greater number of varieties one of the nerves on each side in the first glume, usually the second nerve from the edge, is coarser than the others, is sometimes keellike, and is also usually finely scabrous-hispid above. There are rather wide differences between varieties in regard to coarseness of the nerves and their length from the apex of the glume downward, the latter being closely correlated with the amount of thickening in the glume. The points at which the nerves end are always more or less indefinite, but their length may be approximately expressed in comparison with the length of the entire glume. Differences in regard to coarseness, though sometimes very evident, are still more difficult to denote and these differences can usually be expressed only in general terms.

The nerves on the sides, especially the keellike nerves, frequently extend farther downward than those in the middle. In one or more varieties these lateral nerves are commonly apparent from the apex to the base of the glume, while the remainder extend for about three-fourths or four-fifths the length. In certain other varieties the lateral nerves are visible for about one-third or one-half and the middle nerves for one-fifth or two-fifths the length.

The approximate number of nerves in the first glume has been indicated by some writers, including Hackel (8, pp. 499–520) and Stapf (16, pp. 101–154). To count them in mature spikelets is difficult, on account of the indistinctness of the nerves and the necessity of magnifying them. The ranges found within many varieties are also somewhat wide. The range for the entire sorgo group apparently extends from about 6 to about 18 nerves. Differences between certain varieties in the mean number and the range are apparent, the range in certain of them being from 6 or 7 to about 12, in others from about 12 to about 18, there also being an intermediate class in which the mean number is approximately 12.

COLOR

The colors of glumes vary from pale yellow to deep black, several shades of brown being encountered, including reddish browns, the color being intensely reddened in one or more varieties. Some of the glumes in certain varieties are sometimes grayish or purplish. Glumes are frequently somewhat mottled and often considerably lighter at the apices. Variations in color within types and also within panicles occur, panicles in which the spikelets are in the main black sometimes having some drab, blue-black, grayish, or purplish spikelets. The browns also vary, particularly in the intensity of yellow or red elements. Approximately the average color in each of the four types is shown in Plate XIII. Color is not only often the most evident distinguishing mark, but between certain lines it constitutes the chief describable difference by which the varieties can be separated, being a character which has been used in keys and descriptions by nearly all writers.

FERTILE SPIKELETS OF FOUR VARIETIES OF SORGO. × 6

A, Gooseneck (Sugar Plant No. 021612-17): Obovate spikelets; glumes black except the apex of the first; pubescence mainly deciduous except on the apex of the first glume; awn short, loosely twisted; caryopsis extending as far as or beyond the glumes. *B*, Honey (Sugar Plant No. 0241466): Elliptic and obovate-elliptic spikelets; reddish brown glumes with semideciduous pubescence; awn somewhat loosely twisted; caryopsis not extending as far as the glumes; sterile spikelets light reddish brown. *C*, Red Amber (Sugar Plant No. 01826): Elliptic spikelets; reddish brown glumes; semideciduous pubescence; caryopsis extending as far as the glumes. *D*, Red X (Sugar Plant No. 021691-96): Ovate-elliptic spikelets; reddish brown glumes usually nerved as far as the middle or below; early deciduous pubescence except on the callus; caryopsis extending beyond the glumes, its summit much curved ventrally

Soil and climatic conditions often modify colors considerably. For this reason some varieties when grown in different localities and in different seasons often show some variations in tints and shades. Colors also fade to a certain extent, the greens owing to chlorophyll being largely lost when panicles become mature or are dried for future reference. Other tints also become more or less dull on being dried and with age. All colors mentioned in this bulletin were checked in spikelets of at least three seasons, but under certain conditions of environment the tint or shade may differ from that given.

PUBESCENCE

The fertile spikelet in all of the varieties studied becomes hairy at an early stage, and in the mature state certain kinds show pronounced differences in the abundance and the coarseness of the pubescence on various parts. Differences in the persistence of the hairs are also to be noted, glumes much indurated ordinarily being less persistently hairy. This is shown in Plate II, B, in which the Planter variety (Sugar Plant No. 01816) is represented, the second glume being more indurate and, as will be noted, less hairy than the first. As compared with those on the rachis segment, which usually remain with considerable handling of the panicles, hairs on the glumes are usually less persistent. The term "callus" has been used to designate the slightly elevated or projecting base of the first glume. The pubescence on this portion of the glume in most varieties consists of somewhat tufted hairs, which persist more strongly than those on the back of the glume. In some kinds, however, the hairs on both the back of the glume and on the callus persist strongly, while in others they fall off readily. In some forms hairs on the upper fourth of the first glume persist much more tenaciously than those on the remainder, this being shown in the variety known as Gooseneck. The following distinct differences between varieties are therefore to be noted: (1) Certain ones which naturally shed nearly all the hairs of the glumes, including the basal hairs (Pl. XII, A); (2) one or more which retain tenaciously hairs on the upper fourth of the first glume, but shed most of the remainder of the pubescence (Pl. XIII, A); (3) some kinds in which a greater part of the hairs on the back of one or both glumes strongly persist (Pl. II, B, 1, and Pl. XII, B); and (4) a number of varieties in which hairs on the callus, or the basal hairs, persist much more strongly than the remainder (Pl. XII, C). In some varieties the basal hairs are coarser than those on the back of the glumes, while in others they are about the same, this making a fifth point of difference. The latter, however, does not constitute a very well marked difference.

The minute bristles on the lateral nerves of the first glume vary as to coarseness, tenaciousness, and color. In some types they are thickened, more or less depressed at their points, and deeply colored; in others they are more hairlike and colorless; and in still others they are intermediate between these two in regard to coarseness and are either colorless or only slightly tinted. In a fourth class of varieties such bristles are lacking or found only rarely. The keel of the second glume usually also bears these minute bristles, these being persistent in certain varieties and in others being shed entirely or in part before the seeds are mature.

THE AWN

The sterile lemma, fertile lemma, and palea are for the most part concealed by the glumes, although occasionally they are somewhat exserted at their summits. Their fragile nature also lessens their value for purposes of classification or identification. The awn affords a positive difference, as it is either present or absent. It varies in regard to some minor features, as, for example, length and color, there being appreciable differences between some varieties regarding its length, and there sometimes being a short or rudimentary awn that does not project beyond the glumes, or at least not enough to be easily detected. Panicles have never been found in which the awns were reduced to short projecting points, nor have awned types been encountered in which all the distinctive features of the awn were not generally present—that is to say, in which they were not twisted, geniculate, and scabrous toward the apex. Forms exist which are similar except for the presence or absence of the awn, and it has been possible to isolate from certain mixed populations either an awned or an awnless form. In apparently all varieties the lemmas drop the awns at or before the maturity of the panicle. If, however, the variety has awns, they will always be found in the panicle in greater or less numbers, even in dried specimens, unless they have been handled with undue carelessness.

THE CARYOPSIS

The characters of the caryopsis are useful in helping to differentiate both the principal varieties and the secondary forms, the diversity being in form, color, length relative to that of the glumes, together with minor differences resulting from the variations in form. Comparative length and coloration show pronounced contrasts, and these have been employed by a number of writers. The length has been used by some writers to differentiate groups, and coloration to distinguish between varieties within the groups. Differences in both these characters are useful in keys and in descriptions, but especially in the latter, where they are of value in substantiating determinations made on other features.

The caryopses disarticulate from their rachillas, and in certain varieties they also separate in the main from the spikelets during the threshing process. In the case of some forms, however, only a part of the grains is dislodged, the proportion remaining in the spikelets varying both with the variety and with the severity of the threshing, so that this does not constitute a good character for the purpose of identification. When the glumes remain attached to the threshed seeds or are found intermixed among them in commercial samples, they are usually more or less mutilated or at least have been deprived of their awns, much of their pubescence, and the sterile spikelets. Points of distinction in the caryopsis, although often evident along varietal lines, generally speaking, are not so numerous or so sharply marked as in the glumes, and the extent of variation within varieties pertaining to features of this member is somewhat greater. Although a tendency toward a definite configuration can usually be seen in the caryopses of each type, fluctuations are generally considerable, and differ-

ences in form are consequently often difficult to indicate. For these reasons and also because of alterations that result from fortuitous crossing which occasionally takes place in fields, it is frequently not possible to identify varieties with certainty solely by means of the seeds, although in some kinds the seeds show such plainly distinctive marks that one can be reasonably sure of the variety to which they belong.

Form and minor features.—In apparently all varieties in early stages and until about the time the ovule is fertilized the pistils are essentially straight and more or less regular in form and the styles are situated on a median plane, as evidenced by a lateral view; but as the carpels increase in size, and especially with the development of the endosperm in the ovule, the pistils commence to show diversity in form, this diversity persisting in the mature caryopsis. The differences in form are sometimes such that they are the more plainly seen when the caryopses are viewed dorsally, and sometimes they are more easily distinguished when viewed laterally. From a dorsal viewpoint an elliptic, ovate, obovate, suborbicular, or an intermediate form may be apparent. Some of these forms are shown in Plates XIV and XV. These terms refer to the outline of the caryopsis from a dorsal viewpoint, being thus employed in the descriptions which are given in this bulletin. From a lateral viewpoint the differences primarily relate to whether the axis of the carpel remains essentially straight with the development of the pistil and inclosed ovule into the mature seed or whether it curves toward the ventral side at the summit or at the base. The summit may be either acute, obtuse, or subglobose, depending on the variety, but in certain varieties the axis becomes so curved that the summit, together with the styles, turns considerably in the ventral direction. In some cases also the styles become rotated toward the ventral side, so that their bases which persist on the mature grain can properly be described as being on the ventral half, as would be evident if a longitudinal section were made dividing it dorsoventrally. In certain varieties in which such curving of the pistil occurs, the scar, too, together with the short axis which sometimes remains attached to it, turns somewhat to the ventral side, and in some varieties the scutellum becomes curved and in others it is forced downward or forward. There are on the caryopsis two usually faint lines which extend upward from the scar past the edges of the scutellum to the bases of the styles. There is also sometimes a third line between these two, usually less distinct. These lines under high magnification are found to be strands of elongated cells associated with vascular strands. These are associated with vascular bundles such as have been shown by Walker (*17*) and Schuster (*15*) to be present in the pistils of sorghum and other grasses. From a taxonomic point of view these lines serve to show the extent of bending of the carpel and something about its conformation at the base and the summit, but although various degrees of curving are to be seen in the varieties sharp lines of distinction are usually not possible between the varieties in regard to them, there being forms more or less transitional between those well marked. However, in the case of certain varieties, even where considerable fluctuation is evident, the tendency

toward a definite configuration in the caryopsis which results from the bending of its axis can be discerned, and the average form can be taken as being the one typical of the variety.

Some minor differences in the conformation, as delineated by the periphery and by the longitudinal lines, are of sufficient importance to be noted. These differences pertain to the relation of the thickness of the caryopsis to its width, to the relative thickness below and above the middle, to its form at the summit and at the base, and to secondary features of form. They are usually best seen from a lateral viewpoint. As they are sometimes difficult to describe accurately they can usually best be represented by means of sketches or drawings. Some of them are shown in Figure 1 and in Plates XIV, XV, and XVI, A. Some of these less conspicuous and less important characters are as follows: (1) The scutellum varies in length as compared with that of the entire caryopsis and as to conformation and prominence. Some of these differences have been found to be constant; for example, in one or more varieties most

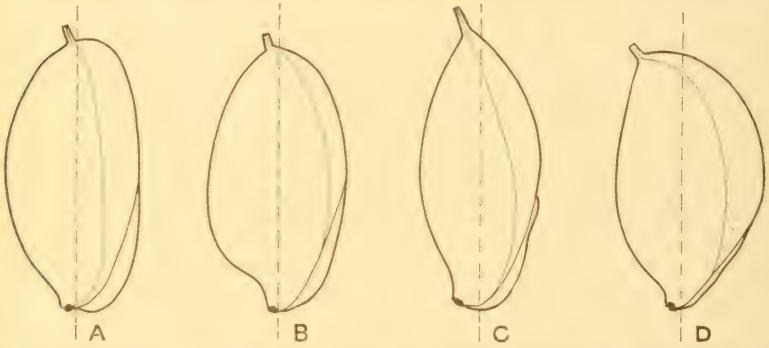
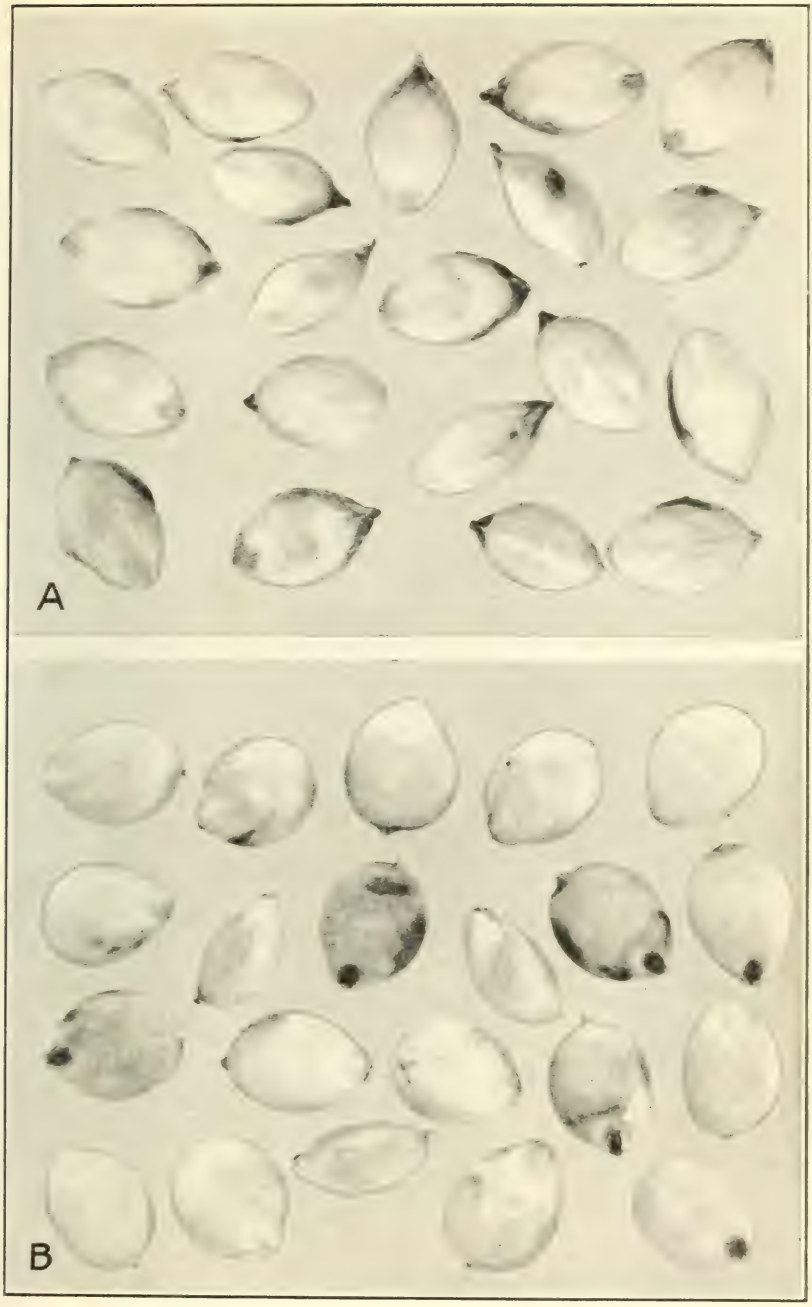


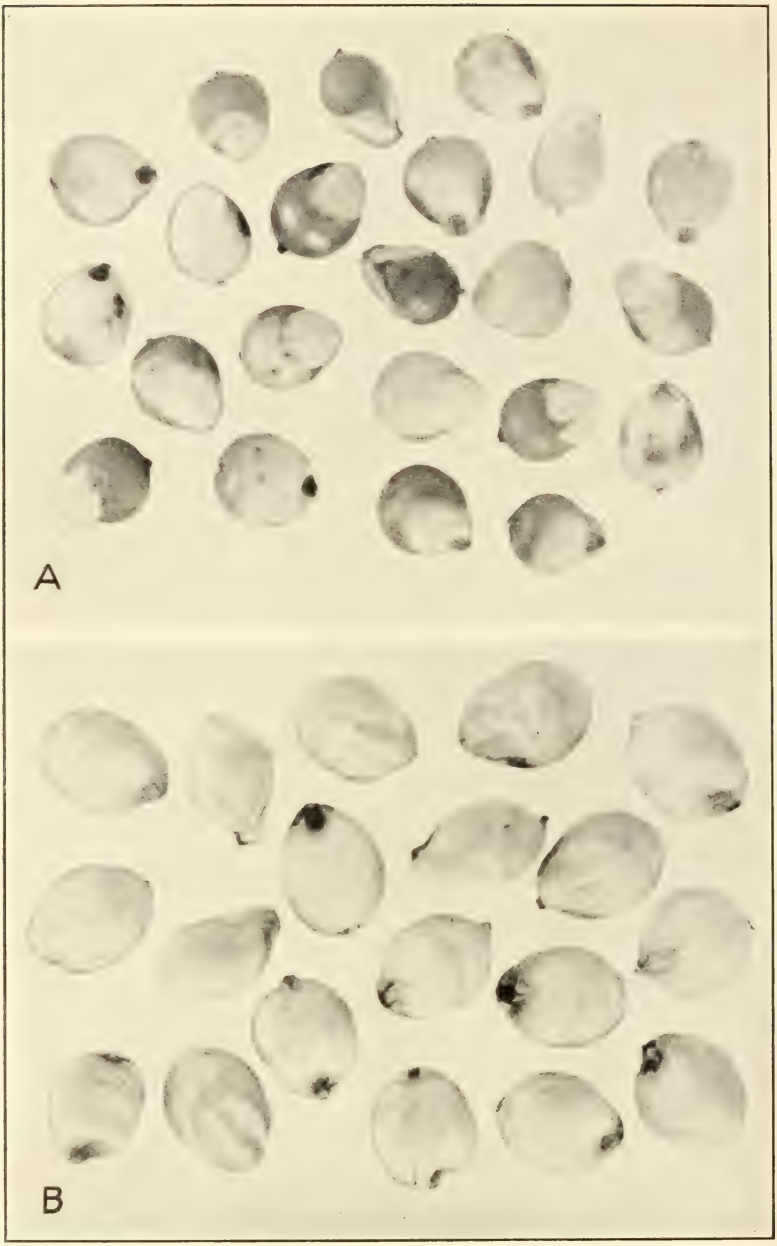
FIG. 1.—Caryopses of four varieties of sorgo: *A*, Minnesota Amber (Sugar Plant No. 0231115); *B*, Folger (Sugar Plant No. 021570); *C*, Orange (Sugar Plant No. 01959); *D*, Red X (Sugar Plant No. 021691–96). The differences in conformation are in part due to differences in curving

of the caryopses show the scutellum prominent; in certain of them it is usually straight and in others it is usually curved. (2) The caryopsis is also sometimes tumescent on the ventral side. (3) The radicle is always prominent in one or more forms. In others it is never conspicuously so; and when this character is used for identification it is necessary to discriminate between varieties in which it only occasionally or slightly projects and those in which it is outstandingly prominent. (4) The pericarp is transversely wrinkled on the ventral side in some varieties. (5) The style bases, in addition to showing differences in direction assumed, are occasionally thickened, and in one or more forms they are seen to originate in a fold of the pericarp. In general, such minor differences are less dependable on account of fluctuation than characters of the glumes. The plumule, for example, is sometimes somewhat prominent, but is not outstandingly and constantly so. So, too, in certain varieties the radicle and the scutellum are somewhat prominent but can not be said to be conspicuously and constantly so.



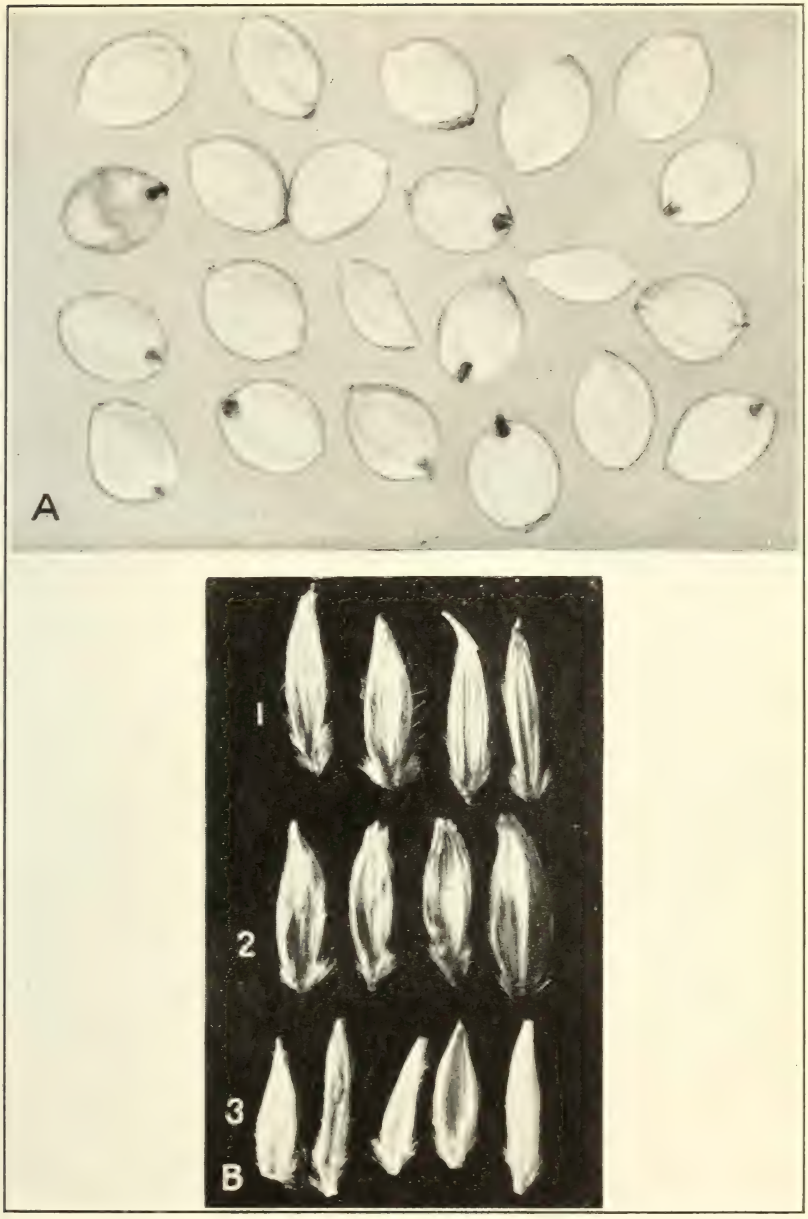
CARYOPSES OF MCLEAN AND RED AMBER VARIETIES OF SORGO. × 5

A, Caryopses of McLean (Sugar Plant No. 0182): obovate-elliptic and ovate-elliptic, acute at the summit; scutellum curved toward the ventral side; radicle prominent; pericarp transversely wrinkled on the ventral side. *B*, Caryopses of Red Amber (Sugar Plant No. 01826): elliptic and obovate-elliptic, rounded at the summit; style bases usually turned ventrally



CARYOPSES OF SUMAC AND GOOSENECK VARIETIES OF SORGO. × 5

A, Caryopses of Sumac (Sugar Plant No. 0181); broadly ovate and broadly ovate-elliptic, the summit globose; scutellum often elevated above the endosperm, projecting downward, and curved ventrally. *B*, Caryopses of Gooseneck (Sugar Plant No. 021612-17); obovate-elliptic and suborbicular; pericarp wrinkled, especially on the scutellum



CARYOPSES OF HONEY SORGO AND STERILE SPIKELETS OF THREE OTHER VARIETIES

A, Caryopses of Honey (Sugar Plant No. 0241466): elliptic, ovate-elliptic, and obovate-elliptic, turned but little at both base and summit; scutellum essentially straight. × 5. *B*, Sterile spikelets of three varieties: (1) Sasnac Amber (Sugar Plant No. 01958), strongly nerved; (2) Indiana Amber (Sugar Plant No. 021697–702), somewhat less strongly nerved and less acute at the apices; (3) Red X (Sugar Plant No. 021691–96), weakly nerved. × 4

Color of the caryopsis.—In general, colors in the caryopsis are lighter than in the glumes. In one variety the caryopses are white, and the differences range through tints and shades of yellow, brown, and reddish brown to chocolate. In some varieties a red element is pronounced, though in none is the color truly red. Where exposed, the shade is usually somewhat darker than where protected from the light by the glumes, and generally the statements made concerning the glumes in regard to inconstancy of color likewise apply to the caryopsis.

RELATIVE LENGTH OF THE CARYOPSIS AND THE GLUMES

A number of writers of keys and descriptions have made use of the extent to which the glumes open and the caryopses are exserted. Among these are Arduino (*1*), Hackel (*8*, pp. 499–520), Stapf (*61*), Pech (*12*), Collier (*5*), and Ball (*2*). Both of these characters are dependent on variation in the comparative size of caryopses and glumes. The opening of the glumes and the protrusion of the caryopsis are both due to increase in the length of the latter beyond the length of the glumes. The caryopsis is not, however, relatively longer in varieties in which it is exserted as compared with other kinds, but, generally speaking, the glumes are relatively shorter. Considered from a phylogenetic viewpoint, therefore, it may be assumed that varieties with exserted caryopses originated from a type with covered grains by the shortening of the glumes along with other parts of the panicles.

In none of our varieties are cases to be found in which the protruding caryopsis is associated with the effuse type of panicle, as was indicated by Schumann (*14*) regarding East African varieties. Since the caryopsis is inserted at the summit of a short axis, there are cases in which it is shorter than the glumes, yet protrudes somewhat beyond them. Four conditions of caryopsis length, as compared with length of the glumes, therefore, really exist: (1) The caryopsis shorter than and not extending as far as the apices of the glumes; (2) the caryopsis shorter than the glumes but extending to their apices; (3) the caryopsis shorter than the glumes but extending somewhat beyond their apices; and (4) the caryopsis actually longer than the glumes. The protruding caryopsis is well shown in the Sumac variety, which is represented in Plate II, C. The amount exserted differs somewhat with the variety. It is impossible, however ,to indicate the extent, and only three conditions are therefore of value for actual use.

THE STERILE SPIKELET

Although the sterile spikelets do not truly disarticulate from their pedicels or the pedicels at their bases from the joints of the rachises of the racemes, in many varieties the pedicels become fragile with the maturing of the panicle, so that they rupture easily, and the spikelets then fall off freely, usually enough remaining, however, to make it possible to determine accurately their form, nervation, pubescence, and other characters. In certain varieties, too, the pedicels remain tough and tenacious, so that in the main they continue attached to the rachis and retain the spikelets, this character being somewhat influenced by the degree of maturity of the panicle.

This deciduous or semideciduous tendency in these spikelets somewhat depreciates all their features for use in varietal identification, and they are so small that they can not be successfully studied unless they are magnified. There are, nevertheless, certain differences distinguishing them which are so distinct and obvious that they merit presentation. The most pronounced relate to their length and prominence, the latter resulting from the combined length of the spikelet and its pedicel.

The range of actual lengths in varieties is apparently not changed except in minor degrees by environmental influences, but the differences in length within the varieties as well as within single panicles is sometimes considerable. In the two varieties between which actual lengths show the greatest differences, the average lengths of the spikelets are 0.18 or 0.20 inch and 0.09 or 0.10 inch, respectively, the approximate extents of each of the two series being shown diagrammatically in Figure 2. This difference in average length of spikelets is sufficient to constitute a good varietal character were it not for their small size, their deciduous tendency, and the variation that occurs within panicles, which make comparisons difficult.

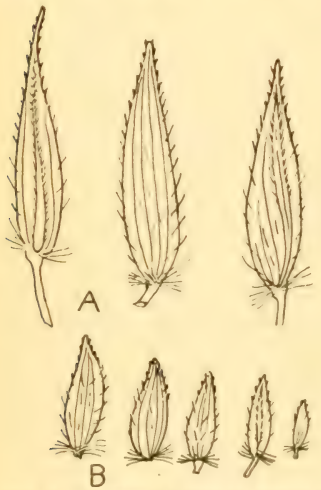


FIG. 2.—Ranges of size in sterile spikelets of two varieties of sorgo: *A*, McLean (Sugar Plant No. 0182); *B*, Sumac (Sugar Plant No. 0181)

In certain varieties the sterile spikelets are so prominent that they give an appearance to the panicle distinctly different from that of some other varieties in which they are hardly visible. Unfortunately, there are also varieties in which the prominence of these spikelets is intermediate between these two extreme types, there being, in fact, a number of transitional types. In certain varieties, however, a predominating number of sterile spikelets, including their pedicels, show a length greater than that of the fertile spikelets at corresponding joints of the rachis. In others the combined length is most frequently less than the length of the fertile spikelets at corresponding joints of the rachis. In a third or intermediate class those in which the combined length exceeds the length of the fertile spikelet and those in which it does not are approximately equal, the difference being so small that a contrast is not discernible. Unless there is a pronounced preponderance in the number of one or the other the characteristic is of little value.

VENATION

Unlike those of the fertile spikelet the nerves of the sterile spikelet always extend the entire length from its apex to its base, and

as they usually are more distinct than those of the fertile spikelet they are somewhat easier to count. The number in the first glume varies from about 6 to about 14. In some varieties it ranges approximately from 6 to 10 and in others from about 10 to about 14. A third class is intermediate, having about 8 to 12 nerves, and the greater number of varieties appear to be in the intermediate class.

The relative distinctness of the venation is somewhat easier to determine than the number of nerves, and although there are a number of stages or conditions of distinctness which are not sharply defined, the extremes, in which the venation is respectively strong and weak, show a considerable contrast. In Plate XVI, B, 1 and 2, are shown spikelets of two varieties in which nerves are distinct, though somewhat less so in the second than in the first; and at B, 3, spikelets of a third variety are shown, the venation in these being faint.

The second nerve from each edge of the first glume is frequently compressed, and it is usually on the edge of the spikelet as viewed dorsally. In some cases these lateral nerves are distinctly coarser than the others, and, like those of the fertile spikelet, they are often keellike. They are to a greater or less extent scabrous-hispid, and there are differences in regard to the coarseness of the minute bristles as well as some differences in the length of the latter. The keel of the second glume is finely hispid in a greater or less degree, and some of the other nerves of the first or second glume are often so to some extent in certain varieties.

PUBESCENCE

The sterile spikelet is always barbate at the callus, and the pedicel is always ciliate on the angles. The edges of the first glume are always ciliate. These types of pubescence are shown in Plate II, D. In one or more varieties both glumes are glabrous except at the callus and on the edges; in others they are pubescent, the pubescence varying as to abundance and fineness and somewhat as to persistence.

COLOR

Color is a somewhat less valuable character in the sterile than in the fertile spikelet, the colors usually being duller, there being no very sharp contrasts, fluctuations also occurring in tint and shade due to fading and to differences in maturity. The extent of the coloration is fully as reliable as the color itself, in some varieties the spikelets being darkest above and in others darkest at the basal end. The pedicel often partakes of the color of the rachis segment, but in certain forms it is more highly colored, resembling the fertile spikelet, this constituting a rather sharp contrast between certain kinds.

SPIKELET PARTS

Certain spikelets show only the two glumes, and others have a number of other floral parts, including two lemmas, the palea, and the two lodicules. The number of members represented differs with the variety, although limits are not sharply marked. Fresh spikelets or those preserved in a liquid can be dissected with little difficulty, and spikelets from dried specimens can also be separated into their distinct members with comparative ease if first soaked in water

a short time. The feasibility of using variations in these features as varietal characters will depend upon whether or not other more plainly marked and easily seen characters are available.

SEX

Stamens are found in some forms, and though they are small and are usually at the base of the spikelet, in certain varieties they show further development. Short filaments are also sometimes found in connection with them.

VARIETAL GROUPS

In presenting the grouping of varieties which follows, no claim is made for its originality in every detail. Considered from the viewpoint of resemblances between the varieties such a classification seems a natural one, and for this reason it has been adopted.

It is the aim to show general similarities and some less important points of likeness as well in a number of varieties considered as a series extending from the much-spreading to the very compact form. It is also the purpose to show how some of the characters described in preceding pages are concerned in the progressive differentiation of the forms. Such an arrangement of these varieties might not be the most adaptable one in a key for identification on account of the close resemblance of some of them.

The major groups seem naturally to be subdivided with respect to certain characters of the spikelet. The order of rank in which the characters by which the varieties are separated into classes and subclasses are considered is as follows: (1) Relative compactness of the panicle, (2) comparative exsertion of the caryopsis, (3) relative degree of thickening in the glumes, (4) form of spikelets, and (5) color of spikelets or caryopses or special features of the panicle or spikelets. The varieties may be divided into three main groups: (1) Effuse, (2) contracted, and (3) compact. In each group the forms may differ in three main characters, relative length of glumes, thickness of the glumes, and the shape of the spikelets. In the synopsis which follows, in order better to correlate these characters, the corresponding subdivisions are indicated by A, AA, AAA; B, BB, BBB; C, CC, CCC. This lettering is followed even though all the groups are not represented by known varieties, in which case the corresponding lettered divisions are omitted.

It is to be noted from the synopsis that in general as the type of panicle becomes more contracted the glumes become relatively shorter. That elliptic spikelets are also relatively less abundant in the more contracted forms also seems apparent, and this may or may not be substantiated with further studies of the sorghums. Certain other points of similarity between varieties within groups became evident in the course of the study. Some of these have been indicated in preceding paragraphs. These and other points of resemblance are brought out in the group descriptions and in the descriptions of the several varieties.

The group taken as the initial one is the effuse, and the variety chosen to represent it is known in our records as Minnesota Amber. There are a number of somewhat similar kinds more or less commonly known by this name, but this one seems to conform best to

descriptions previously published, and therefore it has been accepted as the true type. It does not present the most spreading type of panicle in the effuse group, but in many ways it seems to present the simplest and the one which has been subject to the least alteration. It also lends itself well to description, and it seems therefore to be the natural one to present first.

The names of the other varieties described are for the most part those under which they were received, and the types may not in all cases be those most commonly grown under these names. In each case are shown the chief characters by which the variety being considered differs from a variety which precedes it, usually the one next preceding.

Synopsis of varieties

[SP=Sugar-plant No.]

1. The effuse group:	
A. Caryopses on the average not reaching as far as the apices of the glumes.	
B. Glumes little thickened.	
C. Spikelets averaging elliptic	Minnesota Amber (SP0231115).
BB. Glumes somewhat thickened	(Not represented among varieties studied.)
BBB. Glumes considerably thickened.	
C. Spikelets averaging elliptic	Sasnac Amber (SP01958).
	Mazo Amber (SP0231101).
CC. Spikelets averaging ovate, elliptic-ovate, or elliptic-ovate and elliptic.	(Not represented among varieties studied.)
CCC. Spikelets averaging obovate, elliptic-obovate, or elliptic-obovate and elliptic	Honey (SP0241466).
AA. Caryopses on the average reaching as far as the apices of the glumes.	
BBB. Glumes considerably thickened.	
C. Spikelets averaging elliptic	Red Amber (SP01826).
AAA. Caryopses on the average reaching beyond the apices of the glumes	(Not represented among varieties studied.)
2. The contracted group:	
A. Caryopses on the average not reaching as far as the apices of the glumes.	
BBB. Glumes considerably thickened.	
CC. Spikelets averaging ovate, elliptic-ovate, or elliptic-ovate and elliptic	Collier (SP01960).
AA. Caryopses on the average reaching as far as the apices of the glumes.	
BB. Glumes somewhat thickened.	
CC. Spikelets averaging ovate, elliptic-ovate, or elliptic-ovate and elliptic	Planter (SP01816).
BBB. Glumes considerably thickened.	
C. Spikelets averaging elliptic	Straightneck (SP020386)
	McLean (SP0182).
	SP0221087.
AAA. Caryopses on the average reaching beyond the apices of the glumes.	
BBB. Glumes considerably thickened	Colman (SP021598–603).
C. Spikelets averaging elliptic	Folger (SP021570).
CC. Spikelets averaging ovate, elliptic-ovate, or elliptic-ovate and elliptic	Orange (SP01959).
	Silvertop (SP021618–23).
	Albaugh (SP021645–50).
	Texan (SP021604–09).
	Jones (SP021639–44).
	SP0241523.
	Honey Drip (SP021715–20).
CCC. Spikelets averaging obovate, elliptic-obovate, or elliptic-obovate and elliptic	Gooseneck (SP021612–17).
	Leoti Red (SP0241443).
	Indiana Amber (SP021697–702).
3 The compact group:	
AAA. Caryopses on the average reaching beyond the apices of the glumes.	
BB. Glumes somewhat thickened.	
CC. Spikelets averaging ovate, elliptic-ovate, or elliptic-ovate and elliptic	Sapling (SP021630–31).
	Red X (SP021691–96).
BBB. Glumes considerably thickened.	
C. Spikelets averaging elliptic	Sumac (SP0181).
CC. Spikelets averaging ovate, elliptic-ovate, or elliptic-ovate and elliptic	Sugar Drip (SP021624–29).
	SP0241455.
CCC. Spikelets averaging obovate, elliptic-obovate, or elliptic-obovate and elliptic	White African (SP020222).

DESCRIPTIONS OF VARIETIES

EFFUSE GROUP

The effuse group is characterized by the axes and branches of the panicle being relatively long, the rays well separated, standing out from the axis, sometimes bowed and pendent at the extremities. The axis usually extends to or nearly to the apex of the panicle. It may have a node without rays at the base of the panicle, though this does not occur as commonly in this group as in others. The lowest branches are usually the longest, and the form of the panicle is typically conical. Branches are in general less angular and less pubescent than in the contracted and the compact groups. They are abundantly pubescent at the nodes, but between the nodes the hairs are usually reduced to minute bristles. The glumes cover the caryopses in all the varieties studied which truly belong to this group, or at least the caryopses in these varieties do not commonly extend beyond the apices of the glumes. Five or six varieties so far examined are considered to belong to this group.

Minnesota Amber (*Sugar Plant No. 0231115*).—Panicle subconical or subcylindrical, 8 to 14 inches long, 5 to 8 inches broad, open, spreading; axis usually extending to or nearly to the apex of the panicle, never or rarely having nodes without rays at the base of the panicle, furrowed, pilose at the nodes and sometimes sparsely pilose in the furrows, more or less scabrous-hispid on the ridges, otherwise glabrous; rays somewhat sparse, arranged in three to nine apparent verticils, with occasionally a few interspersed between these whorls, usually ascending at the base, but more or less bowed outward in the middle, the lower rays somewhat flexuous at the base, the longest rays one-third to three-fourths as long as the panicle; secondary and tertiary branches relatively long; branches somewhat flattened or angular below, subterete above, striate, pulvinate, and sometimes pilose or somewhat barbate in the axils, more or less pilose at the base, slightly pilose or scabrous-hispid on the angles, and occasionally slightly pilose in the striations between the nodes, otherwise glabrous; rachises of the racemes ciliate on the angles with coarser hairs than those on the calluses of the fertile spikelets; glumes of fertile spikelet open 10° to 45°, extending beyond or more rarely only as far as the caryopsis and rather loosely investing it, sparsely pubescent with fine soft early-deciduous tinted hairs, those at the base of the first glume the more abundant and more persistent; first glume elliptic or rarely ovate-elliptic (greatest width commonly in the middle), boat shaped or somewhat convex, acute or more rarely obtuse, and occasionally two or more toothed at the summit, commonly not incurved on the sides below but above a little, occasionally infolded on the sides adjacent to the apex, frequently slightly indurate in the lower one-third or two-thirds, not thickened or a little thickened at the base, having a narrow, hyaline, usually ciliate border, blackish brown (Ridgway), or nearly black,[4] shining, not folded back above the callus and not longitudinally creased or wrinkled at the base, 0.18 to 0.25 inch long, 0.10 to 0.14 inch broad, 12 to 18 nerved for the entire or nearly the entire length from apex to base, the second, third, or fourth nerve on each side coarser, keellike, and scabrous-hispid, the bristles usually dark; second glume acute, keeled, the keel often minutely scabrous-hispid above, commonly somewhat incurved on the sides above, not indurate nor thickened, or a very little at the base, having hyaline, or nearly hyaline, and usually ciliate borders of medium width, colored like the first glume, usually bent back and somewhat gibbous at the base, and without longitudinal wrinkles, corrugations, or creases there, usually about 10 to 14 nerved from apex to base; lemma not awned; caryopsis not extending beyond the apices of the glumes, broadly oval or elliptic, more rarely obovate-elliptic or ovate-elliptic, about two-thirds to three-fourths as thick as broad, somewhat more convex on the ventral side, obtuse at both extremities, yellow or brownish yellow (Ridgway, colonial buff

[4] The color terms when so designated are those recognized by Ridgway (*13*).

to honey yellow); scutellum essentially straight longitudinally and its surface conforming closely to that of the caryopsis, about three-fifths as long as the caryopsis but with its outline frequently not completely distinguishable; radicle prominent; longitudinal lines rather obscure, passing along the edges of the scutellum at its base; summit symmetrical or nearly so, but style bases often directed somewhat ventrally; sterile spikelets falling off abundantly by the rupture of the pedicels, compressed and rolled inward at the sides, lanceolate, acute to somewhat acuminate, having both glumes and sometimes a lemma, but without lodicules, neuter, shorter or somewhat longer than the glumes of the fertile spikelet, rarely by as much as one-sixth the length of the sterile spikelet, light yellow to brown, and more or less mottled or spotted, occasionally sessile, or on pedicels as much as one-third as long as the second glume of the fertile spikelet, the pedicel ciliate with hairs somewhat coarser than those of the callus of the fertile spikelet, occasionally reaching beyond the apex of the glumes of the fertile spikelet by as much as one-third its length, by reason of the combined length of the sterile spikelet and its pedicel; first glume about 10 to 16 nerved, the second, third, or fourth nerve on each side commonly on the edge of the spikelet, being coarser than the other nerves and scabrous-hispid above, barbate on the callus and ciliate on the edges, otherwise glabrous; keel of second glume occasionally in view, finely scabrous-hispid in the upper half.

Sasnac Amber (Sugar Plant No. 01958).—Whorls of rays often well separated on the middle of the axis, but closer together below and above and occasionally very compact at the base; glumes of the fertile spikelet somewhat incurved on the sides below, above inflexed, the margins often infolded at the apices, indurate, thickened for the entire length from the base but more thickened below, the margins also thickened, except occasionally in the upper one-fourth or one-third, and with an outer usually hyaline and sometimes ciliate border, opening about the same as in the preceding variety, rather closely investing the caryopsis, the callus occasionally sparsely barbate with somewhat coarse deciduous hairs; first glume obscurely about 12 to 16 nerved in the upper one-fifth to one-half, the second nerve on each side coarse and keellike and scabrous-hispid, the bristles black or blackish and rigid and more or less appressed, black and shining, or occasionally purplish black, usually not bent back above the callus; second glume also thickened, commonly more convex, acute, marked with three or four short faint longitudinal creases at the base, more or less keeled above; awn 0.25 to 0.40 inch long, geniculate, with bend exserted, twisted and dark brown to the bend, but above whitish or yellow and scabrous; caryopsis ovate-elliptic or elliptic, less convex on the ventral side than the preceding; sterile spikelets shorter to about as long as the second glume of the fertile spikelet, their apices occasionally reaching beyond the second glume, yellowish to dark purple drab, frequently darkest at the base, almost sessile or on pedicels sometimes reaching to about one-third the length of the fertile spikelet, sparsely pilose, the callus barbate with coarser hairs.

One or more varieties called Black Amber, Early Black Amber, or Early Amber are similar to this, but differ in the arrangement of the panicle rays.

A variety known as Mazo Amber (S. P. No. 0231101) is similar, but the glumes are reddish brown.

Honey (Sugar Plant No. 0241466).—Panicle conical, somewhat more abundantly branched and usually larger; nodes of the axis frequently somewhat oblique, and each internode somewhat curved just below these nodes; longest rays two-thirds or three-fifths as long as the panicle; ultimate branches fine; axes and branches often reddish brown; first glume of fertile spikelet obovate-elliptic or elliptic (greatest width two-thirds from the base or in the middle), considerably incurved on the sides, the margins not infolded at the apices, reddish brown or sometimes light brown, usually sparsely pilose, the base without more persistent hairs; awn somewhat shorter than in S. P. No. 01958, somewhat more loosely twisted; caryopsis light yellow, light buff, or reddish brown; scutellum approximately conforming with the dorsal surface of the caryopsis; sterile spikelets light yellow to light reddish brown, the darker shade more frequently in the upper half than below.

A variety known as Red Amber (not the one next succeeding) is similar to S. P. No. 0241466, but is smaller growing and earlier maturing.

Red Amber (Sugar Plant No. 01826).—In regard to type of panicle this variety is transitional between the effuse and the contracted types. Panicle somewhat smaller and rays shorter than in preceding varieties; first glume of

fertile spikelet usually broadly elliptic (greatest width in the middle), convex but the one-fourth or one-third at the apex somewhat flattened upwards, more acute than in S. P. No. 0241466, brownish red or reddish brown, folded back at a point above the callus; second glume slightly less thickened than the first, but colored the same, the nerves not perceptible; lemma not awned; caryopsis extending as far as the apices of the glumes or somewhat beyond or short of them, light orange to reddish brown; radicle only slightly prominent; summit usually somewhat turned toward the ventral side of the caryopsis and style bases turned ventrally; sterile spikelets straw color to dark brownish red.

CONTRACTED GROUP

Varieties in the contracted group differ from those in the effuse group in having the panicle branches shorter, with less tendency to spread, and at least some of the branches of each panicle being rigid or semirigid. Panicles are variously formed, partly on account of variations in length of axis and partly because of differences in arrangement of branches and their degree of rigidity.

Collier (*Sugar Plant No. 01960*).—Panicle smaller than in S. P. No. 01826; axis abbreviated to one whorl of a few rays or of various greater lengths, and sometimes extending throughout the entire panicle, somewhat less deeply furrowed; primary rays tortuous or torsive at the base; glumes of fertile spikelet somewhat less thickened, the margins usually infolded at the apices, open 20° to 60°; first glume ovate-elliptic or more rarely elliptic, often flattened dorsally, bent back at the base in the opening of the spikelet, light yellow, dull brown, grayish, or nearly black, often somewhat mottled or spotted, the nerves visible farther down than in the preceding variety; caryopsis usually not extending quite so far as the apices of the glumes, elliptic-obovate, or more rarely elliptic, yellowish or reddish brown; scutellum curved somewhat toward the ventral side at the base; style bases often somewhat thickened, usually on the ventral half of the grain; sterile spikelets more persistent than in the preceding variety, frequently longer than the second glume of the fertile spikelet and reaching beyond its apex by as much as one-half its length, often having a lemma and lodicules, but commonly without stamens.

Planter (*Sugar Plant No. 01816*), *originally known as Planter's Friend.*—Panicle medium size, ovate, obovate, or occasionally cylindric; axis often abbreviated, but usually not to less than about one-fourth the length of the panicle, the pubescence of the axis fine and more uniform than in S. P. No. 01960; rays often flexuous at the base but not torsive; glumes of fertile spikelet open somewhat wider than in S. P. No. 01960, the margins often infolded at the apices, somewhat less thickened, the nerves often extending nearly or quite to the base, loosely holding the caryopsis, light yellow, partly brown, or nearly black, often darkest at the base, abundantly pilose, the hairs more persistent than in preceding varieties except in glumes much hardened, the hairs of the callus being somewhat coarser, the first glume ovate-elliptic or elliptic-ovate; caryopsis somewhat larger than in preceding varieties, reaching to about the apices of the glumes, elliptic-obovate or obovate, the summit turned ventrally, yellowish or occasionally in part light reddish brown; scutellum about as in S. P. No. 01960 or somewhat straighter longitudinally; radicle and style bases about as in S. P. No. 01960, except the latter not thickened; sterile spikelets quite persistent, the pedicels sometimes not rupturing during threshing, light yellow or in part reddish brown.

Straightneck (*Sugar Plant No. 020386*).—Regarding the form of panicle, this variety is transitional between the spreading and the contracted types. Under favorable conditions for growth the rays are long, and many of them are bowed outward, especially near the extremities; panicle usually conical or subconical in form; axis extending to or nearly to the summit, often one or more nodes at the base without rays; branches often ciliate on the angles; glumes of fertile spikelet considerably thickened and open about as in S. P. No. 01826; first glume elliptic, acute, or nearly so, reddish brown (Ridgway, Van Dyke brown),

but usually lighter at the apex; second glume somewhat more concolorous from base to apex; caryopsis obovate-elliptic or elliptic, buff to dull brown (Ridgway, cinnamon buff to sayal brown); scutellum jutting out somewhat at the base from the caryopsis; sterile spikelets deciduous, occasionally with rudimentary stamens.

McLean (Sugar Plant No. 0182).—Panicle open-cylindric; longest rays one-fourth to one-half as long as the panicle; rays standing out from the axis and usually straight; first glume of fertile spikelet elliptic or more rarely obovate-elliptic or ovate-elliptic, black and shining or occasionally blue-gray, except toward the apex for one-sixth to one-fourth the length frequently light yellow; awn not protruding, but its apex occasionally visible at the apex of the second glume; caryopsis extending about as far as the apices of the glumes or more rarely short of them, ovate-elliptic, or occasionally obovate-elliptic, flattened and often transversely wrinkled on the ventral side, commonly obtuse at the base, somewhat acute at the summit, yellowish to reddish brown; scutellum usually less than half as long as the caryopsis, curved at the base toward the ventral side; style bases usually somewhat thickened; sterile spikelets averaging longer than in the preceding variety and somewhat more persistent, sometimes one-fifth longer than the second glume of the fertile spikelet, and frequently reaching beyond its apex by as much as half their length; a lemma together with lodicules or rudimentary stamens often present.

Sugar Plant No. 0221087.—A selection made by the writer (*6*) from an impure accession of Gooseneck (S. P. No. 021612–17). Peduncle occasionally recurved; panicle somewhat more compact and panicle branches more appressed than in S. P. No. 0182; fertile spikelet open somewhat wider; lemma awned, the awn long, geniculate, the bend usually exserted, rather loosely twisted as far as the bend.

Colman (Sugar Plant No. 021598–603).—Somewhat similar to S. P. No. 01826, but panicle a little more compact and axis of panicle often shorter; first glume of fertile spikelet averaging elliptic, reddish brown, the apex frequently somewhat lighter, the lateral nerves sometimes slightly coarser than the others, but without the minute bristles; caryopsis light yellow, light orange, or reddish brown; sterile spikelets falling off readily, light yellow or occasionally in part brown, rarely as long as the second glume of the fertile spikelet, though occasionally reaching somewhat beyond, the lateral nerves of first glume not hispid.

Folger (Sugar Plant No. 021570), formerly known as Folger's Early.—Panicle cylindric or subcylindric, more compact than in S. P. No. 021598–603, but sometimes some of the rays bowed; first glume of fertile spikelet similar to S. P. No. 021598–603, but black and shining and occasionally lighter at the apex, the lateral nerves scabrous-hispid; caryopsis commonly extending beyond the glumes, buff brown (approximately Ridgway, cinnamon buff); sterile spikelets light yellow, often mottled or spotted with dark gray or black, the lateral nerves scabrous-hispid.

Orange (Sugar Plant No. 01959).—Panicle ovate-oval, or somewhat obovate; axis extending to the apex or shortened, occasionally to less than half the length of the panicle, always one and usually two or three nodes at the base of the panicle without branches; branches more or less ascending, but some of them bowed especially near the extremities; both glumes of the fertile spikelet usually marked with short longitudinal creases or corrugations at the base; glumes open about 45° or sometimes more than 90°; first glume ovate-elliptic, more rarely elliptic or elliptic-ovate, strongly incurved at the sides, folded back above the callus, black and shining, or nearly black; caryopsis usually extending beyond the apices of the glumes, sometimes rotated 90° in the spikelet, somewhat flattened on the ventral side; scutellum curved somewhat toward the ventral side at the base; style bases usually turned somewhat to the ventral half of the caryopsis; sterile spikelets light yellow and dull brown, usually lightest at the base, persisting somewhat tenaciously.

Several varieties similar to the last differ chiefly in color of glumes and caryopsis. Among these, varieties designated by the following names have been examined: Silvertop (Sugar Plant No. 021618–23); Albaugh, formerly known as Albaugh Early (Sugar Plant No. 021645–50); Texan, formerly known as Texas Seeded Ribbon (Sugar Plant No. 021604–09); and Jones, formerly

known as Farmer Jones (Sugar Plant No. 021639–44). A selection (Sugar Plant No. 0241523) is similar, but the glumes are occasionally involute.

There are a number of types known as Orange, some of which vary from S. P. No. 01959 only in minor particulars.

Honey Drip (*Sugar Plant No. 021715–20*), *formerly known as Japanese Honey Drip.*—Similar to S. P. No. 01959, but the panicle is more compact, and laterally the caryopsis is usually elliptic-rhomboid.

Gooseneck (*Sugar Plant No. 021612–17*).—Panicle oval, ovate, or occasionally obovate, semispreading or somewhat compact; peduncle occasionally recurved; axis extending to or nearly to the apex or sometimes two-thirds or three-fourths as long; first glume of fertile spikelet obovate, black except in the upper one-fourth or one-third, where often yellowish or yellowish brown, pilose with persistent hairs in the upper one-fourth or one-third; awn short, brown at the base, loosely twisted, the bend exserted or more rarely included; caryopsis when fully developed extending somewhat beyond the apices of the glumes or more rarely short of them, broadly obovate-elliptic, suborbicular, or elliptic, yellowish or brown, often darkest where having been exposed; pericarp often wrinkled, especially over the scutellum; sterile spikelets more or less inflated and tending to open at the apices, occasionally having two lemmas, the palea, the lodicules, and stamens, the stamens sometimes on short filaments, sessile, or more commonly on pedicels; first glume flattened; second glume with the keel often prominent.

A variety known as Leoti Red (Sugar Plant No. 0241443) somewhat resembles Gooseneck. The peduncle is not recurved, the panicle is a little more effuse, and the glumes are light reddish brown.

Indiana Amber (*Sugar Plant No. 021697–702*).—Panicle ovate, oval, or obovate, averaging smaller than in S. P. No. 021612–17; peduncle erect or slightly bent; axis varying in length from one-third or one-half the length of the panicle to the entire length; glumes of fertile spikelet commonly open about 60° to 90°, first glume obovate or occasionally obovate-deltoid, obtuse, or somewhat acute, much thickened, black and shining, the nerves usually visible only in the upper one-fifth or one-fourth and the lateral nerves coarse and scabrous-hispid with somewhat thickened black or blackish bristles; awn similar to that in the preceding variety, but darker, often black at the base; caryopsis extending beyond the apices of the glumes, dorsally broadly elliptic, broadly obovate-elliptic, or broadly ovate-elliptic, laterally irregularly elliptic or elliptic-rhomboid, more or less laterally tumescent and transversely wrinkled on the ventral side; style bases originating in a fold of the pericarp, sometimes somewhat to the ventral half of the caryopsis; sterile spikelets nearly sessile or on black pedicels as much as one-third as long as the second glume of the fertile spikelet, compressed and frequently rolled inward at the sides, usually light yellow and black or dark brown, usually darkest below, shorter, or rarely a little longer than the second glume of the fertile spikelet, occasionally reaching a little beyond its apex.

COMPACT GROUP

Panicle branches are in general shorter, more rigid, and more angular than in the preceding group, the axis usually more deeply furrowed and both axis and branches more abundantly pubescent. There are commonly one or more nodes without branches at the base of the panicle. In all varieties examined the caryopsis is exserted.

Sapling (*Sugar Plant No. 021630–31*).—Regarding the type of panicle, this variety is transitional between the contracted and the compact groups. Panicle narrowly cylindric or subcylindric, longer, and somewhat more compact than in the preceding varieties, lowest node of panicle most frequently without rays; ridges of the axis often ciliate; longest rays one-fourth to two-thirds as long as the panicle, sometimes inclining outward and the entire branch sometimes pendent; secondary branches comparatively short; first glume of fertile spikelet ovate-elliptic or occasionally elliptic-ovate, somewhat indurate and thickened, but thickened little in the upper half, obscurely nerved, the nerves usually extending more than half the length downward from the apex and the lateral not hispid or occasionally with very minute bristles, black, or brownish, or very

light yellow, frequently darkest at the base and sometimes more or less mottled, without longitudinal corrugations or creases at the base; caryopsis extending well beyond the apices of the glumes, yellowish or brown; style bases on the ventral half of the grain and turned forward; sterile spikelets somewhat inflated or somewhat compressed, light yellow, weakly nerved, the lateral nerves often having minute bristles.

Red X (*Sugar Plant No. 021691–96*).—Similar to S. P. No. 021630–31, but panicle shorter, a little more compact, and the spikelets somewhat more crowded; glumes of fertile spikelet reddish brown (Ridgway, maroon) or lighter; caryopsis yellowish or orange-brown, usually darkest where having been exposed.

Sumac (*Sugar Plant No. 0181*).—Panicle more compact and somewhat smaller than in S. P. No. 021691–96, 5 to 9 inches long, 1.5 to 3.5 inches broad; axis usually reaching more than two-thirds to the apex; lowest node most commonly without rays, this node usually close to the next; rays short and rigid; axis and branches more pubescent, the branches hairy on the angles; spikelets crowded; first glume of fertile spikelet elliptic or more rarely ovate-elliptic or obovate-elliptic, usually obtuse at the summit, dark brown or nearly black at the base or farther up and dull yellow above, or all dull yellow, 0.12 to 0.14 inch long, 0.7 to 0.10 inch broad, usually more persistently pubescent than the second glume, obscurely nerved as far as one-third or two-thirds the length downward from the summit; second glume more darkly colored, somewhat more indurate and the nerves more obscure; caryopsis broadly obovate or broadly elliptic-obovate, the globose summit somewhat turned toward the ventral side, orange-brown or yellowish below and reddish brown above where exposed (Ridgway, chocolate or lighter); scutellum curved toward the ventral side at the base, often jutting out at the base from the endosperm and extending considerably lower, usually of the lighter color; sterile spikelet small, shorter than the second glume of the fertile spikelet, and rarely reaching beyond its apex, light yellow and light reddish brown; lateral nerves of first glume sometimes hispid to the base.

Sugar Drip (*Sugar Plant No. 021624–29*).—Similar to S. P. 021691–96, but with glumes more indurate and more thickened, black or occasionally dark brown except at the apices dull yellow; first glume usually with faint corrugations at the base; second glume with longitudinal creases; nerves of the first glume not perceptible below the upper third or half; caryopsis usually somewhat browner than in S. P. 021691–96; sterile spikelets more strongly nerved.

Sugar Plant No. 0241455 differs from S. P. 021624–29 chiefly in that the glumes of the fertile spikelet are reddish brown.

White African (*Sugar Plant No. 020222*).—Panicle cylindric or obconical; axis usually much abbreviated, sometimes to less than one-fourth the length of the panicle, deeply furrowed; rays ascending, coarse, and usually close together; secondary branches relatively short; first glume of fertile spikelet obovate-elliptic or elliptic, indurate, and thickened about as in the preceding variety, black or occasionally dark brown, but frequently light yellow at the apex, the nerves apparent only in the upper one-third or one-half and the lateral nerves with or without minute bristles; caryopsis obovate-elliptic or elliptic, the summit turned a little toward the ventral side, white but sometimes having brownish spots or blotches; sterile spikelets light yellow or almost white.

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